BIOLOGICAL STUDIES IN HAWAIIAN WATER-LOVING INSECTS

PART III

DIPTERA OR FLIES
D. CULICIDAE, CHIRONOMIDAE AND CERATOPOGONIDAE

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(Presented at the meeting December 13, 1943)

FAMILY CULICIDAE (The Mosquitoes)

It is probable that man has given more attention to the mosquito than to any other insect. The reason for this is obvious. Mosquitoes generally bite man, they are almost worldwide in distribution, and to that extent are a pest. They are frequently transmitters of disease and may be well adapted to man's habitat; there are day mosquitoes as well as those addicted to a night life. And while all mosquitoes require water for the development of their early stages, there are species suited to almost every type of water—pure fresh water, befouled fresh water, brackish water and water saltier even than the sea itself.

For all our knowledge of these noxious insects there still remains a very great deal to be learned about them. The life-history of many species, particularly in the tropics, is not known or but incompletely so, while it is a common belief that mosquitoes breed in tall grass or luxuriant herbage. Then again, the relatively much larger as well as quite harmless crane-flies (Tipulidae) often pass for mosquitoes of record size.

A typical mosquito has a slender piercing beak or proboscis, and the body, legs and wings are largely clothed with scales. The males have great plumose antennae—a character however, common to many other kinds of nematocerous flies. The hum of the mosquito is characteristic.

There are but three species of mosquitoes found in the Hawaiian Islands; two that are active in the daytime and one that is active at night; and while this is quite enough, our far-flung archipelago has fewer species of mosquitoes than many other Pacific islands; Samoa for example with 7 species, Fiji with 17 and Guam with 6.

Only the female mosquito bites, the male having mouth-parts not fitted for piercing the skin, feeds on nectar and plant juices. Not all species of mosquitoes are harmful; the genus *Megarhinus* for example, composed of large handsome species that as adults are plant feeders, are carnivorous in the larval stages, devouring the

young of other mosquitoes that live in tree holes, the butts of bamboos, rain barrels, etc. An attempt was made to establish a New Britain *Megarhinus* in the Hawaiian Islands, and although a considerable number of the mosquitoes were successfully introduced, conditions were not suitable for its maintenance at large; in the more tropical Fiji Islands however, a Javanese *Megarhinus* was introduced and successfully established. Mosquitoes of the genera *Psorophora* and *Mucidus* as larvae, devour the young of other mosquitoes but in the adult stage are vicious biters.

Much according to group, mosquitoes lay their eggs singly, in groups, or as "rafts". They are deposited on or near the water, and some kinds can endure prolonged draughts. The larva has four instars or stages of growth. It feeds by means of its mouth brushes that when in motion produce a current that brings small particles of food towards the mouth, or by nibbling algae, dead plant tissue, etc. with its well-formed mandibles. The posterior or respiratory end of the larva terminates in the siphon which connects with the tracheal or oxegenating system, and the anal gills the chief function of which is to absorb water (Wigglesworth, V. B.; The Function of the Anal Gills of the Mosquito Larva. Jour. Exper. Biol., **10**: 16-26, 1933). In *Anopheles* the anal siphon is so short as to be practically wanting, while in *Taeniorhynchus* it is sharply pointed for piercing the tissues of aquatic plants and from which oxygen is thus obtained. Mosquito larvae are adept swimmers, outstripping the larvae of any other aquatic flies known to me.

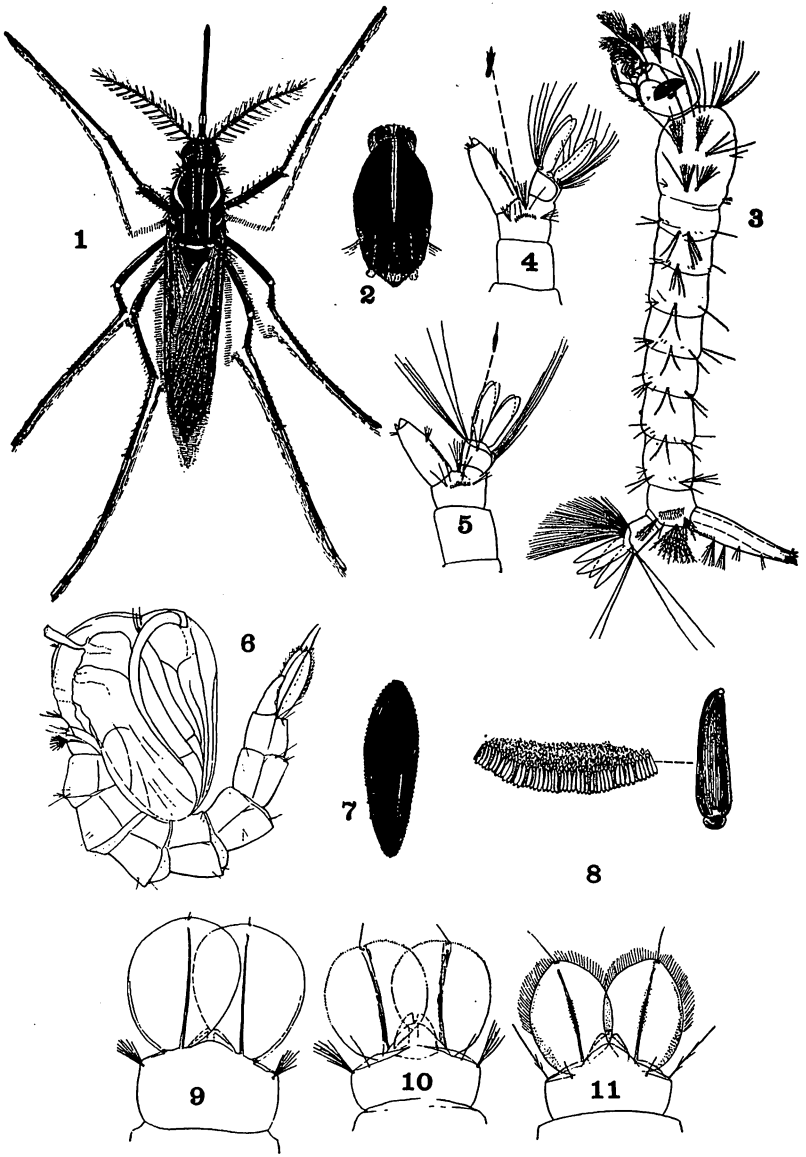
At the last moult the fourth instar larva is succeeded by the pupa. This humped and also active stage is likewise quite familiar to the casual observer. The pupa breathes by means of a pair of respiratory trumpets situated on the back of the thorax. It swims by vigorous strokes of the abdomen which terminates in a pair of broad paddles. When the time for the eclosion of the adult is at hand, the dorsum of the thoracic integument splits and the teneral adult works its way out, clings to the floating pupal shell for a while and finally takes wing.

As with other nematocerous flies the male mosquito has a

MOSQUITOES

EXPLANATION OF PLATE III

1. *Aedes aegypti,* female. Length 6.5 mm. Oahu.
2. *Aedes albopictus,* female, thorax, from above. Oahu.
3. *Culex quinquefasciatus,* larva, last stage. Length about 7 mm.
4. *Aedes aegypti,* larva, last stage, caudal end.
5. *Aedes albopictus,* larva, last stage, caudal end.
6. *Aedes albopictus,* pupa.
7. *Aedes albopictus,* egg. Bronzy black with fine white reticulations.
8. *Culex quinquefasciatus,* egg raft.
9. *Culex quinquefasciatus,* pupa, swimming paddles.
10. *Aedes aegypti,* pupa, swimming paddles.
11. *Aedes albopictus,* pupa, swimming paddles.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swarming habit. We sometimes see, or hear such swarms—of a very high pitch—in the darker part of an open room, or outside by the trunk of some tree or other large plant growth. Females fly into such swarms and mating then takes place.

The statement that the female mosquito first requires a meal of blood in order to deposit viable eggs may be generally true, but exceptions have been found. As regards *Culex pipiens* Linn., to quote Riley and Johannsen (Medical Entomology, : 216, 1938): "De Boissezon (1929) likewise found that this species would oviposit if fed with apple juice alone, and both he and Huff reared larvae from eggs deposited by females which had had no food whatever subsequent to the larval stage."

Mosquitoes have many natural enemies, but inasmuch as they so often get into the breeding places first, transform so rapidly and in such numbers, they gain the advantage over such predators as the larvae of dragonflies, of certain carnivorous flies, water beetles and bugs. Bugs like the slender marsh-treader (*Hydrometra*) often spear wrigglers with their beaks, and our little *Mesovelia* and *Microvelia* bugs would probably attack emerging mosquitoes. Certain predaceous flies, i.e. among the Dolichopodidae and Anthomyiidae are mosquito enemies. In the Anthomyiidae, for example, Dr. W. A. Lamborn (Bull. Ent. Res., **11**: 279-281, 1920) noted a species of *Lispa* fly preying upon mosquito larvae and emerging and crippled adults in a pool near Kotakota, Lake Nyassa, Africa, and: "In the Federated Malay States Dr. Lamborn (1921) saw a species of *Lispa* carrying on their useful work in such numbers that he attributed the entire absence of *Anopheles* larvae from certain pools and ponds partly to their agency". (Evans, A. M. E., Trans. Ent. Soc. London, **78**: 325, 1930). P. Tate (Parasitology, **27**: 556-560, 1935; Cambridge) found the larva of the anthomyiid fly *Phaonia mirabilis* Ringdahl to be predatory on mosquito larvae at Cambridge, England. It bred in the water found in tree holes. The *Phaonia* larvae were very voracious and killed many more mosquito larvae than they would eat.

However, by far the most efficient enemies of mosquitoes in waters accessible to fish, are the little top minnows or killifish, long ago imported into Hawaii and many other countries for mosquito control.

The artificial control of mosquitoes is effected by applying the proper methods, by cooperative effort and concentrating first of all on the elimination of the breeding places.

Culex quinquefasciatus Say. (plate figures 3, 8 and 9).

Say, T., Journ. Acad. Nat. Sci. Phil., **3**: 10, 1823.

(= *Culex fatigans* Wiedemann, 1828).

This is the common widely distributed night mosquito. It has been with us for well over a hundred years, having arrived here

presumably from San Blas, Mexico, in the ships' supply of water. It has a brownish thorax, the legs are nearly concolorous and the abdomen pale banded. It may occur wherever there is standing fresh water, and it has been seen in temporary ponds, puddles, pools befouled with decaying guava fruit and other organic matter. It breeds also in rain barrels, water troughs and other water containers. The eggs are deposited to the number of several hundred in the form of a raft that floats lightly upon the surface of the water. They hatch in a day or two, the wrigglers descending directly into the water from a rupture made in the thicker lower end of the egg shell. The larval or wriggler stage lasts from 10 to 14 days approximately, while the pupal stage is about 2 days, so that the entire life-cycle may not exceed two weeks.

The anal siphon of the larva of this *Culex* is much longer than in our two day mosquitoes.

Culex quinquefasciatus is sometimes wind-borne well into the mountains and elsewhere, and it is chiefly this species that may take shelter in our automobiles in garages.

Aedes aegypti (Linn.). (plate figures 1, 4 and 10).

Linnaeus, C., Hasselquists' Reise nach Palestina: 470, 1782. (*Culex*).

This is the yellow fever mosquito and also a carrier of dengue fever. It is less common here than *Aedes albopictus* and distinguished from it chiefly by the lyre-like markings on the dorsum of the thorax in contrast to the conspicuous median stripe of *albopictus*. The larva of *aegypti* has the "comb" on the siphon-bearing segment consisting of tridentate bristles, whereas in *albopictus* the bristles of the comb are simply sharp points arising from a wider basal portion (compare figs. 4 and 5).

Aedes albopictus (Skuse). (plate figures 2, 5, 6, 7 and 11).

Skuse, Indian Museum Notes, 3: 20, 1895 (*Culex*).

This is the commoner of the two day mosquitoes and the less domiciliary one, as it very often breeds in our mountains, where I have seen its larvae and pupae in numbers in the rot hole in the bole of a large kukui tree (*Aleurites moluccana* [L.]). In and about the city its early stages may be passed in tree cavities containing water, in the water at the leaf bases of such plants as *Bilbergia, Crinum, Alocasia* and *Pandanus,* as well as in such water-containing receptacles as barrels, buckets and the saucers for flower pots.

Aedes albopictus is considered less effective in the transmission of dengue fever than is *Aedes aegypti.*

Aedes albopictus, commonly regarded as an Oriental species has sometimes been confused with the Australasian *Aedes scutellaris* (Walker) that occurs in the Pacific as far east as Fiji. For distinc-

tions between these two species see Edwards, Bull. Ent. Research, 7: 209-210, fig. 5, 1917; and l.c., 14: 370-371, 1924.

FAMILY CHIRONOMIDAE (The Non-biting Midges)

The members of this family range in size from minute flies to those equalling large mosquitoes. They are separable from the Ceratopogonidae, with which they were formerly associated, by a number of characters, among which are: wings lying rooflike over the back instead of flat over the back, as with the Ceratopogonidae, and the presence in the Chironomidae of a median groove in the metanotum. Finally, the Chironomidae usually are not as thickset as the Ceratopogonidae, and there are also distinguishing characters in the immature stages.

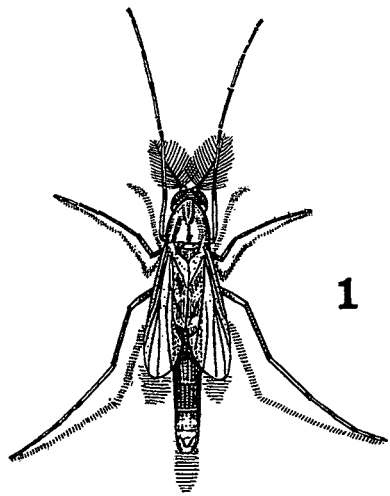

Fig. 1. *Chironomus hawaiiensis,* male. About the size of a mosquito.

In his review of the Hawaiian diptera, with descriptions of new species (Proc. Hawaiian Ent. Soc., 8, 1934) on page 446, E. H. Bryan, Jr. records 7 species of Chironomidae. Further collecting by me, together with the discovery of 2 new species of *Telmatogeton* in the collection of the H.S.P.A. Experiment Station, has brought the total to at least 17 species. Inasmuch as 7 of these 10 additional species were taken on the Island of Oahu, it is very probable that many other species in this difficult group exist in our Territory.

I have derived much help in this work from the fine memoirs of the Cornell University Agricultural Station, on Aquatic Diptera, 1937—Mem. 205, part 3, by O. A. Johannsen; Mem. 210, part 4, by the same author, and part 5 (Ceratopogonidae) by Lillian C. Thomsen. Other indispensable works are those of F. W. Edwards

on the British biting midges (Ceratopogonidae) and the British non-biting midges, in the Trans. Ent. Soc. London, for 1926 and 1929, respectively, and J. R. Malloch's "Chironomidae or midges of Illinois"; Bull. Ill. State Lab. **10** (6), 1915. In addition, there are many more special papers that should be consulted.

Edwards (Trans. Ent. Soc. London **27**: 286, 1929) divides the Chironomidae into five subfamilies, of which three are represented in the Hawaiian Islands. These are the Chironominae, the Orthocladiinae and the Clunioninae, the last division including our marine species.

SUBFAMILY CHIRONOMINAE

Here belong the genera *Chironomus* and *Tanytarsus,* probably our most aquatic midges. Both are large genera in many other parts of the world, but in Hawaii only two species of *Chironomus* and one of *Tanytarsus* have been recognized. Both of these genera play a very important part in the economy of nature and are often the chief food of certain fish. As a rule, they are of little annoyance to man; their large swarms may rarely cause some inconvenience, while the bloodworm larvae of *Chironomus* sometimes breed in water tanks, whence they may be carried in tapwater to the wash bowl. *Tanytarsus* also, may gain entrance into similar tanks and other receptacles.

Chironomus hawaiiensis Grimshaw. (plate IV and text figures 1, 2 and 3).

Grimshaw, P. H., Fauna Hawaiiensis, 3 (1): Diptera: 4, 5, 1901, ♂ and ♀, Oahu, Waialua, Koolau range; Feb. 1893. pl. I, figs. 6 and 7.

Of this chiefly dull greenish brown, mosquito-size insect Dr. R. C. L. Perkins says (Fauna Hawaiiensis, **1,** Introduction): "*Chironomus Hawaiiensis* is one of the commonest of insects, especially near the coast or on the lowlands. Its status as a native insect is very doubtful. Being freely attracted to light, it often swarms in the verandah of houses, and forms a considerable part of the food of some of the lizards that haunt the same situation." It breeds—at first opportunity—in static or slowly flowing water, patronizing reservoirs, ponds ditches, overflows, taro and rice fields, untidy street gutters in wet districts, etc. In newly filled reservoirs, as yet unstocked with fish, it may occur in almost incredible numbers —first as elastic, nearly transparent jelly-like cylinders in which the eggs are imbedded and that wave gently at the water level from herbage, rocks or banks; then as freely-swimming, almost colorless young larvae; then as larger blood-red larvae undulating in or reaching from tubular retreats, or at large; and at last as active pupae. Under severe competition, so often its lot, *Chironomus* manages to exist among dense aquatic vegetation, such as blankets of algae.

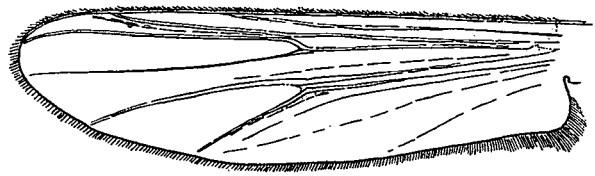

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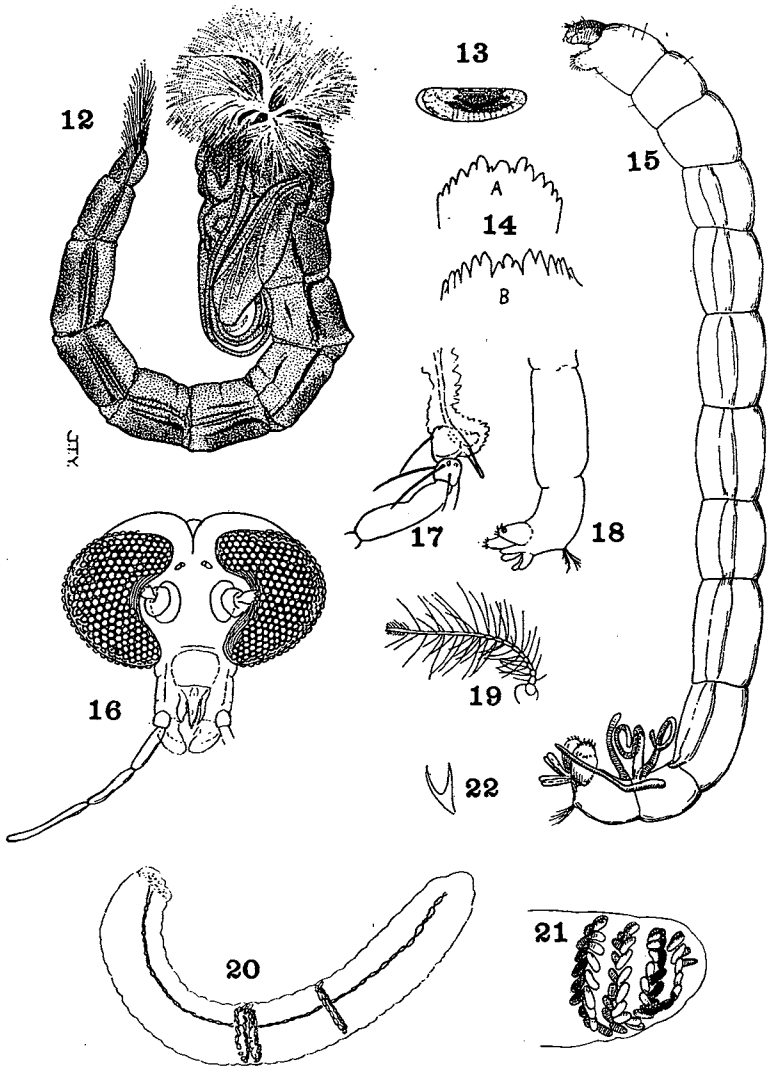
Fig. 2. *Chironomus hawaiiensis,* male wing.

The egg cylinder or rope of this species of *Chironomus* is from about 12 to 18 mm. or more long. In its periphery are imbedded many hundreds of eggs, each about 0.33 mm. long and arranged in alternating right and left loops. A pair of fine twisted fibres runs through the length of the cylinder, which is securely fastened to some object by a short stem. These slippery egg masses would not easily be grasped by fish or fowl.

The newly hatched *Chironomus* larva is nearly transparent and somewhat thicker at the thorax. There are two dark eye-like spots on the head. The anterior and posterior pairs of prolegs and the caudal gills and hair tuft are present. For some time the larva swims about freely in figure-8 fashion, but finally settles down to construct a tube of debris or whatever material is at hand, to serve as a shelter. As it grows and moults it assumes a reddish color due to the presence of free haemoglobin which assists in respiration by functioning as a carrier of oxygen. After probably the first moult, two pairs of elongate gills appear on the ventral surface of the eighth abdominal segment. Larvae may be found in numbers in their tubes that are fastened to the bottom or the sides of the pool, tank, etc. Here they may be seen reaching out from their tubes to grab flocculent mud, portions of algae, diatoms and other material as food or building material. Presumably to aid in respiration the larva frequently undulates rapidly in its tube. The pupa does this also but in less vigorous fashion. The pupa is provided with branching gill tufts of hoary white filaments that project from the prothorax, while at the depressed tail end are two rows of bristles that aid in locomotion. When the time for the eclosion of the adult nears, the pupa leaves its retreat and eventually by means of strenuous wriggling, reaches the surface; here it swims in aimless fashion and finally succeeds in breaking the surface film, an air-silvered portion of the thoracic dorsum then dryly protruding. Now the back of the thoracic integument splits apart, the adult insect almost pops out of this gap and, in a matter of a few seconds flies off with a mosquito-like hum. After an emergence of *Chironomus,* the widely-gaping pupal shells may be seen floating at the surface of the water.



CHIRONOMUS

EXPLANATION OF PLATE IV

12. *Chironomus hawaiiensis,* pupa.
13. *Chironomus hawaiiensis,* egg. Length 0.33 mm.
14. *Chironomus hawaiiensis:* A, mental plate; B, of *Chironomus* sp. from Wailau, Molokai.
15. *Chironomus hawaiiensis,* mature larva. Length about 13 mm.
16. *Chironomus hawaiiensis,* female, front view of head.
17. *Chironomus hawaiiensis,* adult, maxilla.
18. *Chironomus* sp. mature larva, caudal end. Wailau, Molokai.
19. *Chironomus* sp., male, antenna.
20. *Chironomus hawaiiensis,* egg string; only a few eggs shown. Length of string 14.5 mm.
21. *Chironomus hawaiiensis,* egg string portion, more enlarged.
22. *Chironomus hawaiiensis,* larva, posterior pseudopod hook.

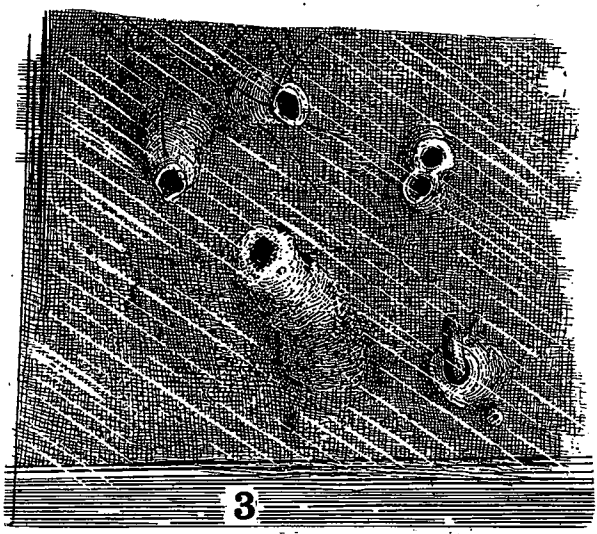


Fig. 3. *Chironomus hawaiiensis* larval tubes in the mud under water. Enlarged.

The male of *Chironomus hawaiiensis* has densely plumose antennae.

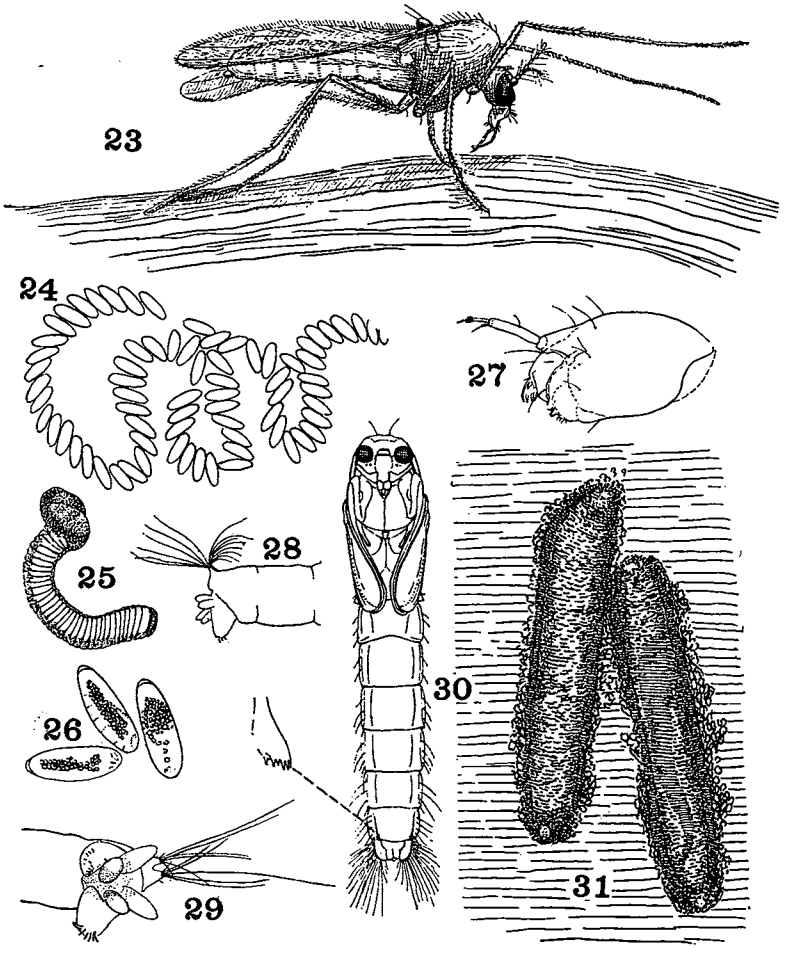
Adult *Chironomus* as well as *Tanytarsus* commonly rest with the forelegs held more or less horizontally in the air like antennae.

Chironomus species. (plate figures 14B, 18 and 19).

Of a much duskier shade than *Chironomus hawaiiensis,* the male with the antennae only thinly plumose and differing also in other characters from our common species, is a *Chironomus* the writer found in a tiny spring at an elevation of nearly 3000 feet above sea-level, near Wailau summit, above Mapulehu, Molokai, in December 1937. Here several adults were obtained, while among finely rooted grass in the water were some bloodworm larvae, undoubtedly of this species. Note that the larva lacks the ventral gills that are so conspicuous on the eighth ventral segment of *C. hawaiiensis* beyond the first stage.

Species of *Chironomus* have numerous enemies, such as dragonflies, water beetles, aquatic flies and bugs, and fish. *Hydrophorus pacificus* Van Duzee, a common Hawaiian dolichopodid fly pulls the bloodworms out of shallow water and greedily consumes them. Even *Cyclops,* a tiny crustacean destroyed newly hatched *Chironomus hawaiiensis* larvae. *Cyclops* would make a short dash at a larva, hold it for a moment, severely wounding it, or, more at length consumed a good portion of its prey.

Much has been written on *Chironomus.* An excellent paper on *Chironomus cristatus* Fabr. is by Miss Hazel Branch, in the Journal



TANYTARSUS

Explanation of Plate V

23. Female. Experiment Station, H.S.P.A., Honolulu. Length of body 1.5 mm.
24. String of 72 eggs. Diffused by placing in water.
25. String of eggs. As deposited.
26. Eggs, more enlarged. Length of egg 0.26 mm.
27. Larva, head, last stage. Length of larva 3.8 mm.
28. Larva, caudal end, from side.
29. Larva, caudal end, from beneath.
30. Pupa, ventral view. Length 2.9 mm.
31. Pupal cases. Length 5 mm. Experiment Station, H.S.P.A., Honolulu.

of the New York Entomological Society, **31**: 15-30, 3 pls., 1923. Another fine paper is Wm. O. Sadler's "Biology of the Midge *Chironomus tetans* Fabricius, and Methods for its Propagation" (Cornell University Agric. Exp. Sta.; Mem. **173**: 1-25, 2 pls., 2 figs. and 20 tables, 1934). As stated by Dr. Sadler on page 3: "The purpose of the study was to determine the practicability of propagating midge larvae as a forage crop for young fish that feed mainly on living organisms." Finally, "The Natural History of Aquatic Insects", by Professor L. C. Miall, London, 1895, gives a very interesting account of *Chironomus*.

Tanytarsus lacteiclavus Grimshaw. (plate V).

Grimshaw, P. H., Fauna Hawaiiensis, **3** (1): 5, Diptera, 1901. Kauai, Koholuamano, six males and two females, April 1895.

Those of us who are familiar with our mountain streams, be they ever so small, have probably observed swarms of pale green gnats hovering low over the water. These swarms, as far as observed, are composed entirely of male *Tanytarsus;* frail little flies with bushy antennae, dark eyes and a pale green body, the thorax of which is marked with deep brown. The individuals in a swarm may be seen working their way forward in the mass and then swinging to the rear.

And while *Tanytarsus* is abundant in the environment, as described, it is likewise common—presumably as the same species—in lowland reservoirs, lily and fish ponds, ditches, water tanks and even in water-containing saucers of flower pots in greenhouses.

In the laboratory, tank-bred females laid eggs, to the number of about 100, as little transparent masses or stout banners 10 or 12 minutes after issuing from the pupa. When the egg-masses are immersed in water they expand as feeble gelatinous cords. The eggs themselves are nearly transparent and about 0.26 mm. long. More than one lot of eggs may be laid by a single female. Incubation is less than two days, the glassy larva literally bursting out of a pressure rent in the shell; then there is a vigorous squirm and all but the tail end is immediately freed. The tiny larva is a good swimmer but soon settles down to construct a simple tube of debris that may be open at either end, attaching it to the substratum. Older larvae are largely greenish. The antennae are relatively long, there is a pair of prolegs at each extremity of the body and in addition posteriorly, finger-like gills and a double tuft of bristles. The pupa is pale glassy green. It may often be seen actively undulating within its debris chamber that is very thinly closed. When the time for hatching is at hand the pupa leaves its case, floats or swims to the surface and the adult issues without loss of time and flies away. This transformation was observed on numerous occasions in the grounds of the Experiment Station, Hawaiian Sugar Planters' Association, Honolulu, in the summer of 1939. Here several iron

drum tanks filled to a depth of 28 or 30 inches with water made to circulate very gently were used by a special research laboratory for studying the growth of sugar cane, a stalk of which was inserted in the water. Algal growth had developed on the sides and on some surface apparatus. Eventually *Tanytarsus* midges appeared, and I was glad of the opportunity to study the habits of these little green insects so conveniently situated. No swarming of *Tanytarsus* was ever observed here, for all seemed to be females. The larvae and pupae appeared at some depth in the drum. The flies emerged chiefly in the afternon, although no night watch was kept. Where a moment before nothing had been observed on the surface of the water, several adult *Tanytarsus* are now to be seen. However, by watching carefully one might discover a little silvered pupa rising up in a subvertical position from the sunlit depth. Progress is fairly rapid and occasionally hastened by brisk sculling; a spot breaks the surface of the water, head, thorax and appendages appear and, with a slight pull the end of the abdomen of the delicate green midge is freed from the gaping almost invisible pupal shell. A moment's rest and the midge takes wing. The entire transformation at the surface was a matter of from 17 seconds to a little more than a minute. All the *Tanytarsus* observed and reared from this iron drum tank were females, a number of which were captured immediately after emergence and found to lay viable eggs. From one such egg mass I reared a single adult, a female. This recalls an article by F. W. Edwards entitled: "Some Parthenogenetic Chironomidae". Ann. & Mag. Nat. Hist., (9) 3 (14) : 222-228, 1919). Here he shows that several species of Chironomidae, including *Tanytarsus boiemicus* Kieffer, are able to reproduce without the intervention of the male.

Tanytarsus is sorely beset by enemies. Damselflies and dragonflies plunge into their lazy swarms, while the larvae and pupae of these midges form an important element in the food of the nymphs of these Odonata. Hawaiian fresh water goby fish, or oopu, take their toll. And as these frail flies emerge from their pupal shells at the surface of the water, particularly among algae in a quiet pool, the little water-running bugs *Microvelia vagans* (White) pounce upon them to impale them on their beaks. Nevertheless, for all these handicaps, there are many places where *Tanytarsus* breeds unmolested and, thanks to its adaptability, maintains itself in abundance.

There are several species of marine *Tanytarsus* in the Pacific. Two of these occur in the Samoan Islands (Edwards, Insects of Samoa, **6,** Diptera, fasc. 2 : 62, 1928), while four others have been described from Japan (Tokunaga, "Chironomidae from Japan

(Diptera), II. Marine Tanytarsus", Philippine Jour. Sci., **51**: 337-368, 2 pls., 1933). The writer took a species of *Tanytarsus* flying about the seashore at Noumea, New Caledonia, in July 1940. It appears surprising that no marine *Tanytarsus* have been found in the Hawaiian Islands.

For an excellent article on *Tanytarsus dissimilis* Johannsen in Minnesota, see Cavanaugh, W. J. and Tilden, J. E.: "Algal food, feeding and case-building habits of the larva of the midge fly, *Tanytarsus dissimilis*", Ecology, **11**: 281-287, 3 pls., 1930.

SUBFAMILY ORTHOCLADIINAE

Here belong a few species of small size, the least known and perhaps the least aquatic group of our Chironomidae. The males may be seen in swarms in the moist mountains or in gardens—and particularly over fresh compost—in the city itself. This subfamily and the Clunioninae may be separated from the Chironominae in having the first joint of the fore tarsus shorter than the tibia, as well as by other characters. From the Clunioninae, which follows this subfamily, it is distinguished by the presence of a well defined horizontal pleural suture (anepisternal suture) and by the male antennae being usually plumose.

Grimshaw in Fauna Hawaiiensis, 3 (1): 5, Diptera, 1901, noted an unnamed species of *Orthocladius*.

Another undescribed species has been referred by Johannsen to the subgenus *Psectrocladius* (Bryan, E. H. Jr., Proc. Hawaiian Ent. Soc., 8 (3): 404. In 7 (2): 233, 1928 of the same journal, Dr. J. F. Illingworth reported that Dr. J. M. Aldrich had determined a tiny green midge which had been bred from water cultures, as *Metriocnemus* sp. (Chironomidae). The larvae of these flies constructed tubes on the walls of the dishes, reaching their heads out to feed and retracting when disturbed. "Two specimens had

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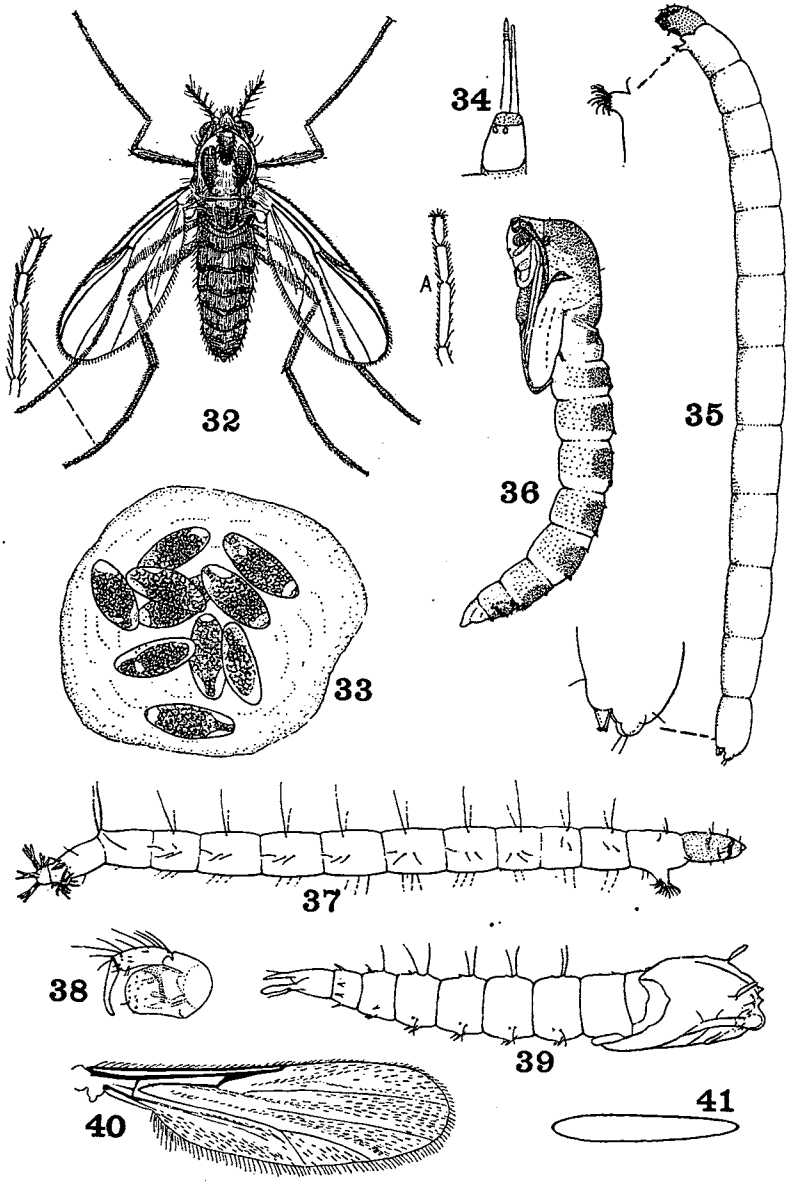
SPANIOTOMA and APELMA

Explanation of Plate VI

32. *Spaniotoma* sp. female, Mt. Kaala, Oahu, 3600 ft. elevation. Length 1.5 mm.; A, *Spaniotoma* sp., female, part of hind tarsus. Honolulu.
33. *Spaniotoma* of 32A, globule of eggs.
34. *Spaniotoma* of 32A, antenna of larva.
35. *Spaniotoma* sp., larva, Mt. Kaala, Oahu, 3600 ft. elevation.
36. *Spaniotoma* sp., pupa. Length 3.3 mm. Mt. Kaala, Oahu, 3600 ft.
37. *Apelma brevis*, larva, last stage. Length 3.7 mm.
38. *Apelma brevis*, male, part of terminalia.
39. *Apelma brevis*, pupa. Length 2.6 mm.
40. *Apelma brevis*, male, wing.
41. *Apelma brevis*, egg. Length 0.47 mm.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been previously bred from material collected in a lily pond by Mr. O. H. Swezey". This very much suggests *Tanytarsus*. I have made but a single specific identification in this subfamily.

Spaniotoma (Smittia) maculiventris Edwards.

Edwards, F. W., "Marquesan Insects—II", B. P. Bishop Museum, Bull. **114,** Pac. Ent. Surv., Publ. 7: 89, 1935. ♂. "Uahuka: Putatauua, Vaipaee Valley, altitude 880 feet, September 20, 1929, one male on dead banana leaves, Adamson."

"A species with extremely distinctive coloration."

I took numerous examples of this small midge in Honolulu, during January 1941 and 1943. The males were hovering in swarms over leaf compost, the females were perched nearby. This species, probably an immigrant, is prettily marked in yellow, rich brown and black; the male is more slender and has bushy antennae, the female is more heavily marked on the abdomen with black. The larva is probably terrestrial.

Spaniotoma No. 2 (plate figure 32).

Slightly larger than the preceding. The female is 1.5 mm. long, the male longer. The head and thorax are pale yellowish, the mesonotum having three dark and wide parallel stripes, the abdomen is grayish green, darker apically, and the legs grayish. This species is common about a spring at 3600 feet altitude, on Mt. Kaala, Waianae Mts., Oahu. Some of these flies were taken on foliage by this spring in 1938 and 1939, while a number were reared from masses of fine roots and diatomaceous material that were water soaked or sheeted over with water. The larva and pupa (figs. 35 and 36) taken from this locality may be this species.

Spaniotoma No. 3 (plate figures 32A, 33 and 34).

About 1.35 mm. long and with the median stripe extending the entire length of the mesonotum. A few females were taken, chiefly on windows in Honolulu. One of these laid 10 eggs as a glassy globule on the wet cotton stopper of a test tube. The eggs measured about 0.24 mm. long. A well-grown larva has a well developed anterior proleg; the posterior proleg is less developed and is sparsely provided with a few strong hooks. The larvae kept more or less submerged in some felt-like algae. They were unable to swim. The pupa much resembles that figured (36) from Mt. Kaala. It is provided with 3 bristles on each side near the eyes, while at the caudal end are 2 spines on each side of the gently bilobed median part, the outer spine the longer. The abdomen is finely roughened.

Spaniotoma No. 4.

One pale colored female specimen of what appears to be a *Spaniotoma* with some macrochetae along the wing veins. From Palikea, Waianae Mts., Oahu, 2,000 ft., November 15, 1936, on mossy ground.

Metriocnemus No. 1.

One male and 2 females of a hairy-winged midge that appear to belong to this genus. Mt. Olympus, Koolau Mts., Oahu, 2,100 ft. Reared February 2-9, 1939 from muddy moss.

The female is the more hairy winged.

Metriocnemus No. 2.

Six males from the spring at 3,600 ft., Mt. Kaala, Oahu, November 13, 1937 and December 26, 1938. On foliage.

A good account of the early stages of *Metriocnemus lundbecki* Johannsen in Illinois, is given by Dr. J. R. Malloch in Proc. Ent. Soc. Washington, **16**: 132-136, 1 pl., 1914.

SUBFAMILY CLUNIONINAE

In his key to the known genera of Clunioninae, Edwards ("Diptera of Patagonia and South Chile"; British Museum Publication, **2,** [fasc. 3]—Chironomidae: 31, 1931) places seven genera. Two of these—*Telmatogeton* and *Clunio* are represented in the Hawaiian Islands.

About 12 species of *Telmatogeton* have been recognized. The genus has representatives in South Africa and the Indian Ocean, South Australia, Japan, the Marquesas and the Hawaiian Islands and South Chile. With the exception of four Hawaiian species that inhabit mountain streams they are marine insects. A fifth species found along Hawaiian seashores was first taken in the Marquesas Islands to the south.

The habits of these insects are of great interest, and the Hawaiian species particularly need further study. They do not hover in swarms as do many other midges to the contrary; nevertheless the males especially, are very active insects and may often be seen racing about as if distraught—half running, half flying at the very margin of mountain torrents, rushing flume waters, or over wave-washed sea rocks. The eggs are laid singly or in groups where they are submerged or at least wet; the larvae construct more or less of a silken tube and seem incapable of swimming; the pupae are cylindrical with a large chitinous disk terminating the posterior extremity.

Telmatogeton pusillum Edwards.

Edwards, F. W. "Marquesan Insects—II", B. P. Bishop Mus., Bull. **114,** Pac. Ent. Surv. Publ. 7: 88, 89, 1935. "Eiao: Vaituhu, October 2, 1929, 6 males, 3 females at light, Adamson."

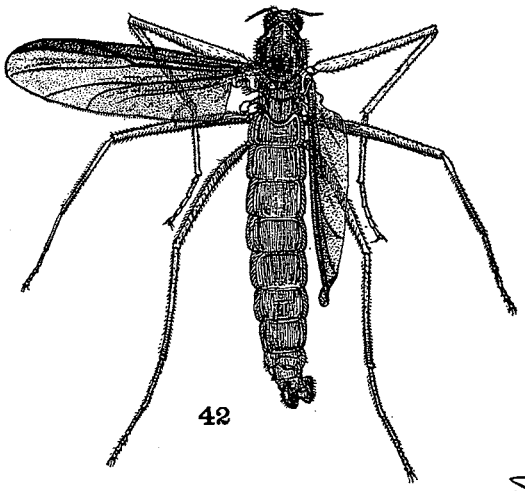
Specimens taken on a wave-drenched boulder at Waimanalo, Oahu, June 3, 1936, were identified by Mr. Edwards (at the British Museum) as this species. It is also found on the Waianae shore of Oahu. The adult fly measures from a little less to a little more than 2 mm. long and seems to be the smallest described species. The general color is brownish with the thoracic dorsum more or less gray pruinose and the wings a sort of dull smoky whitish, dark at the costa. It is long legged and ungainly. It is common at the upper tide belt where there is plenty of tufted oakum-like, pale yellowish green algae of the genus *Ectocarpus* (*Phaeophyaceae,* or brown algae). Here it may be seen racing in erratic fashion over the tide-washed rocks, and then taking wing. It appears able sometimes, to withstand the impact of the waves, for when one of these has receded the fly is immediately to be seen resuming its dodging course over the rocks. I have not observed it avoiding a wave by flight, as does to the contrary the little canacid fly of the sea rocks.

This fly was difficult to capture when active but could be bottled readily enough while at rest on coral ledges. When a stone bearing a quantity of *Ectocarpus* was immersed in fresh water, a number of *Telmatogeton pusillum* larvae appeared. These rather sluggish, non-swimming larvae had dark brown heads and olive green and brown bodies with sparse erect hair and anterior and posterior hook-bearing prolegs. At eclosion the pupa is extruded from its neat tubular retreat. The eggs were not observed.

TELMATOGETON

Explanation of Plate VII

42. *Telmatogeton torrenticola,* male. Length 5.5 mm. East Molokai.
43. *Telmatogeton torrenticola,* larva. Length 14.5 mm. East Molokai.
44. *Telmatogeton* sp., eggs. Waianae, Oahu.
45. *Telmatogeton* sp., pupa. Length 7.5 mm. Waianae, Oahu. Appendages loosened from proper position.
46. *Telmatogeton* sp., pupa, caudal end, viewed obliquely dorsad. Waianae, Oahu.
47. *Telmatogeton* sp., pupa, breathing horn and side of thoracic dorsum. Halemanu, Kauai.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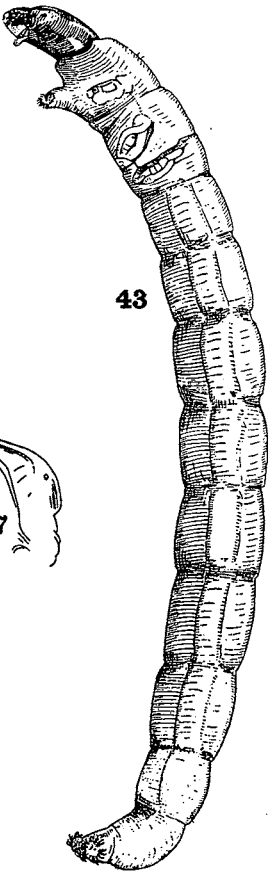
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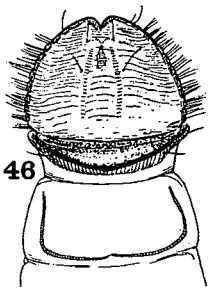
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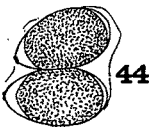
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This fly is sometimes found in company with *Clunio* sp., a smaller marine dipter.

Telmatogeton abnormis (Terry).

Terry, F. W., Proc. Hawaiian Ent. Soc., 2: 292, 295, plate 7, figures 6, 7, 8 and 9, 1913 (*Charadromyia* Terry). Habitat, Kilauea, Kauai.

This fresh-water species measures about 2.7 mm. in length of body. It has thus far been found only on the island of Kauai.

Telmatogeton sp. 1. (plate figures 44-46).

This insect has been confused with *T. torrenticola* of Maui and Hawaii, from which it differs by its smaller size, the character of the tarsal claws, etc. It is more nearly related to *T. abnormis*. It occurs both in the Koolau and the Waianae ranges of Oahu. While usually inhabiting well-forested regions it has in some cases followed swift-water ditches to the more open lowlands. It has for example, established itself in the hot semi-arid Waianae valley where it breeds along the algal margins of a cement-lined ditch that carries swiftly-running water. Here the adult fly often falls victim to the foraging fire ants (*Solenopsis geminata* [Fabr.]).

Dr. J. F. Illingworth, in a short paper entitled "Insects in the Waiahole Ditch" (Proc. Hawaiian Ent. Soc., 7: 408-409, 1931) reported this insect as one of the chief constituents of masses of insects that piled up in a back eddy of this long open canal: The floating mass was composed largely of their pupae and cast larval skins. The adults were emerging in numbers." This *Telmatogeton* is common along rapid streams that have their origin behind Honolulu. In upper Manoa valley it is usually found at waterfalls, but I have seen an individual frantically racing about an area of less than a square foot on a steep wetted rock in a stream. It is often swept downstream but works its way up again. In its apparently aimless but swift progress at the water's edge it often collides with the dense groups of *Scatella* flies busy with courtship and feeding activities. Sometimes several male *Telmatogeton* in seeking to court the quieter female became involved in quite a tangle. The shining, dark-tipped eggs are found in clusters slightly under water or at its edge. Eggs kept in the laboratory hatched in about a week. The dusky olive larvae are non-swimming, provided with the usual prolegs and almost devoid of hair. They live in silk-lined tubes among algae that may be more or less exposed in the rapid marginal water; or they may be submerged an inch or two, where for example water curves swiftly over a rounded boulder. On one rock plane that was shallowly sheeted by rapid water their numerous silken-white galleries showed very conspicuously.

Telmatogeton torrenticola (Terry). (plate figures 42 and 43).

Terry, F. W., Proc. Hawaiian Ent. Soc., 2 (5) : 292-294, plate 7, figures 1-5 and 10-16, 1913 (*Charadromyia*). "Hab. Types ♂ and ♀ Nahiku, Maui (400-800 ft.) also Lahaina, Maui (1000 ft.); Kohala, Hawaii (1200-1500 ft.) Terry coll."

"In rapid streams and waterfalls". It appears to be this species that is found in the mountains of Molokai.

This is a duskier and much larger species than the two preceding, for it attains a length of body of about 5.3 mm. and a wing length of 5 mm. Besides occurring along mountain streams it is a common sight about rapid ditch water and along the often very swift water in the wooden flumes that traverse fields of sugarcane.

Terry (l.c.) has notes on the life history of this midge. The eggs are .3 mm. long and are deposited in single layers "often consisting of several thousands in a mass, evidently the product of several females". The larvae are at first greenish and later olivaceous and attain a length of 18-20 mm.

The fly probably has its share of enemies, but my only note on this subject refers to what seemed to be quite an ambitious *Lispocephala* fly (Anthomyiidae) attempting to overcome a *Telmatogeton* midge about as large as itself, at Akaka Falls, Hawaii.

Telmatogeton sp. 2 (plate figure 47).

This is our largest chironomid and apparently the largest species of the genus—in a series of ten specimens the body length ranges from 4.6 to 7.10 mm. while the wing length ranges from 6 to 7.7 mm. Apart from its superior size however, it is readily distinguished from the others by the relatively long and erect hair on the legs. It was taken on the Kauaikinana stream at Kokee, Kauai, September 6, 1919, by H. T. Osborn. The altitude here would be over 3000 ft.

Some of the marine *Telmatogeton* have received considerable study and the reader is referred to the following papers:

Hesse, A. J. 1934 "Contributions to a Knowledge of S. African Marine Clunione-Chironomids; (A) The Early Stages and Ecology of *Telmatogeton sancti-pauli* Schin. (= *Trissoclunio fuscipennis* Kieff.) from the Cape Coast." Trans. Royal Ent. Soc. London, **82** : 27-40, 4 text-figures.

Tukunaga, M. 1935. "Chironomidae from Japan (Diptera). 4. The Early Stages of a Midge, Telmatogeton japonicus Tukunaga". Philippine Jour. Sci., **57** : 491-511, one text-figure, 3 pls.

Womersley, H. 1936. "An Interesting Chironomid *Telmatogeton australicus* sp. n. from a South Australian Reef." Records of the South Australian Mus., **5** : 439-443, 2 text-figures.

The genus *Clunio* (text-figures 4-6) consists of very small marine flies, the males between 1 and 2 mm. in length, with broad milky white wings, the females without wings. It is represented on the coasts of Europe, Japan, Samoa and the Hawaiian Islands, including Midway Island. These flies breed in the intertidal zone, but the European *Clunio marinus* Haliday may also be found in its immature stages among the algae to a depth of 15 meters (Goetghebuer, M. "Faune de France, 23, Dipteres Chironomidae", 4: 143, 1932). The larvae which are provided with anterior and posterior prolegs, construct shelters of silk interwoven with sand and debris.

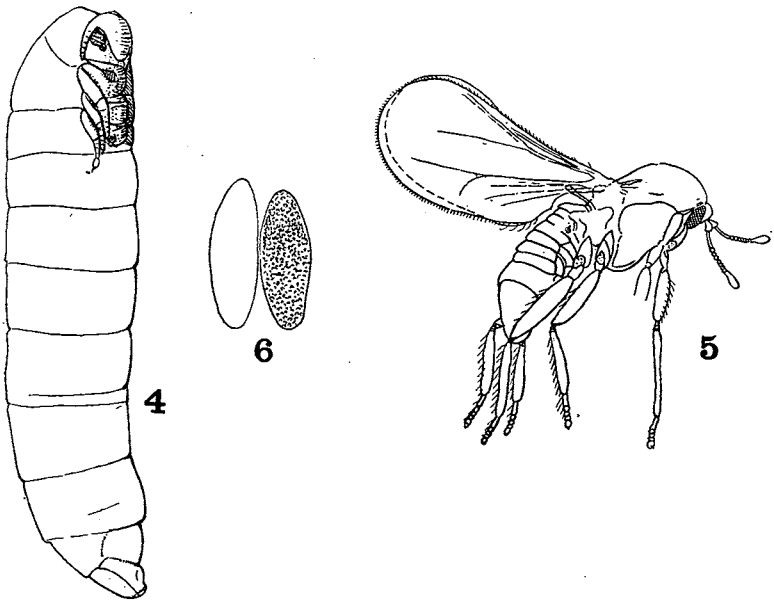

Fig. 4. *Clunio* sp., female pupa. Enlarged. Hanauma Bay, Oahu.
Fig. 5. *Clunio* sp., male. Enlarged. Midway atoll.
Fig. 6. *Clunio* sp., eggs. Length 0.24 mm.

The male *Clunio* are very active in their wild scampering progress low over the wet sea rocks, as they search for females exposed by the receding tide. One or more males would locate a female among the short green rock algae. Pairing was brief, the attached male buzzing its wings, the female remaining on the substratum. A few pairs were captured by means of a suction apparatus, or aspirator. A female that was confined in a vial laid a long gelatinous string of eggs, the latter being arranged at right angles to this string.

Males were often seen floating in little rock pools.

A series of *Clunio* taken at three points on Oahu: Hanauma Bay, Waimanalo and the Waianae coast were sent to the British Museum where Mr. F. W. Edwards determined them as three apparently undescribed species, each from its own locality. The writer also took male *Clunio* on the beach of Midway atoll, 1300 miles northwest of Honolulu, in the summer of 1941. But probably the earliest capture of *Clunio* in the Hawaiian Islands is represented by a male specimen taken by Mr. O. H. Swezey at Kaimuki, Honolulu, November 10, 1915.

Among the papers referring to marine Clunioninae are:

Edwards, F. W. 1926. "On Marine Chironomidae (Diptera); with Descriptions of a New Genus and Four New Species from Samoa"; Proc. Zool. Soc. London: 779-806; figs.

Buxton, P. A. 1926. "The Colonization of the Sea by Insects: with an Account of the Habits of *Pontomyia*, the only known Submarine Insect"; Proc. Zool. Soc. London: 806-814.

Saunders, L. G. 1928. "Some Marine Insects of the Pacific Coast of Canada"; Ann. Ent. Soc. America, **21**: 521-545; figs.

Tokunaga, M. 1933. "Chironomidae from Japan (Diptera) I. Clunioninae"; Philippine Jour. Science, **51**: 87-99; 2 pls.

FAMILY CERATOPOGONIDAE (The Biting Midges)

This is a large family of small flies, the females usually of stout form, the males more slender and with bushy antennae. Their larvae may be aquatic, subaquatic or terrestrial. The family is lucidly dealt with by Edwards ("On the British Biting Midges [Diptera, Ceratopogonidae]"; Trans. Ent. Soc. London, **74**: 389-426; pls. XCI-XCII and 3 text figs., 1926.).

While our few Ceratopogonidae appear to be of little economic importance, the family elsewhere contains many serious pests—i.e. those of the genera *Culicoides, Ceratopogon, Lasiohelea* and *Leptoconops*. These are often referred to as punkies, no-see-ums and sand flies. Several are disease carriers.

A number of species of Ceratopogonidae suck the blood of insects, attaching themselves to the wings or the body of their host. Among these hosts are dragonflies, butterflies, crane-flies (Tipulidae), mosquitoes and the caterpillars of butterflies and moths.

Among the papers referring to this subject, are:

Knab, F. 1914. "Ceratopogoninae sucking the blood of other insects"; Proc. Ent. Soc. Washington, **16**: 139-141 (hosts: *Anopheles, Culex* and Lepidoptera).

Macfie, J. W. S. 936. "Four Species of Ceratopogonidae (Diptera) from wings of insects"; Proc. Royal Ent. Soc. London, B. Taxonomy, **5**: 227-230 (hosts: Odonata and tipulid flies).

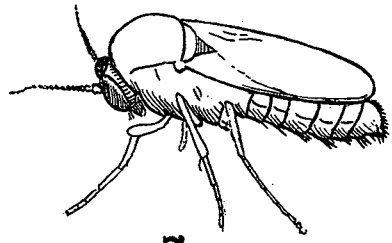

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Fig. 7. One of the Ceratopogonidae, female. Enlarged.

Macfie, J. W. S. 1937. "Notes on Ceratopogonidae"; ibid: 111-118 (hosts: Odonata and the larva of the noctuid moth *Laphygma exempta*).

Lever, R. J. 1940. "A Ceratopogonid fly attacking a caterpillar in Fiji"; Ent. Mo. Mag., (IV) **1**: 55; note by F. W. Edwards.

In the Island of Trinidad, B.W.I., a species of *Forcypomyia* is considered as most probably a cross-pollinator of the cacao tree (*Theobroma cacao* L.) (Billes, D. J., 1941. Tropical Agriculture, **18** (8): 149-156).

E. H. Bryan, Jr. in his "Review of Hawaiian Diptera, with Descriptions of New Species" (Proc. Hawaiian Ent. Soc., **8**: 405, 447, 1934), lists *Apelma brevis* Johannsen and three *Ceratopogon* species, of which one was determined by Dr. Johannsen as the subgenus *Prohelea*. The writer took four species of this family in the Hawaiian Islands, as follows: *Forcypomyia ingrami* Carter, *Apelma brevis* Johannsen, *Dasyhelea hawaiiensis* Macfie and *Dasyhelea calvescens* Macfie. Additional species should be found here.

Apelma brevis Johannsen. (plate figures 37-41).

Johannsen, O. A. "A New Midge injurious to Pineapples (Diptera, Ceratopogoninae)". Proc. Ent. Soc. Washington, **29**: 205, 207-208, 1927. Describes ♂ and ♀ and larva and pupa. *Apelma* is placed under *Forcypomyia* by Edwards.

This is a tiny brownish midge somewhat over a millimeter in length. It was observed by Dr. J. F. Illingworth as—"omnipresent in the water pockets in the axils of pineapple leaves—" (Proc. Hawaiian Ent. Soc., **7**: 206, 1929). Subsequently, Dr. Illingworth (ibid, **8**: 541-543, 2 figs., 1934) gives a brief account of its life-history and habits. He gives the incubation period of the dark cigar shape eggs as four days, the length of the larval stage from 28 to 45 days and the pupal stage four days.

The adults may be seen in small numbers flying in jerky zigzag fashion about pineapple plants (*Ananas sativus* Schultes, Bromeliaceae).

Most of my observations on this insect were made in November 1938, in a long abandoned planting of pineapples in the forehills of Punaluu valley, Oahu. Many young plants were examined. In addition to *Apelma,* larvae of the curious fly *Stenomicra orientalis* Malloch (Asteidae), of sidling gait, were observed breeding between the leaves.

The eggs of *Apelma* were found fastened for their length towards the tip of one of the innermost leaves and well above any axillary water. The pupa is active but cannot swim.

Forcypomyia ingrami Carter. (plate VIII).

Carter, H. F., Ann. Trop. Med. and Parasit., **12**: 290, 1919. Described from West Africa. Ingram and Macfie, Ann. Trop. Med. and Parasit., **18**: 584, 1924.

Occurs also in the Marquesas Islands, Samoa, Sumatra, Malaya, Trinidad, (B.W.I.) and doubtless elsewhere.

Forcypomyia ingrami is probably a widespread insect in the Hawaiian Islands. On the big island of Hawaii it has been taken at Kilauea, 4000 ft. (O. H. Swezey) ; and at Nauhi, 5200 ft. (O. H. Swezey and F. X. Williams) ; on Oahu it has been collected from the lowlands to the highest peak (4028 ft.). It may be very common in Honolulu during the wetter months—when more breeding places exist—the adults hovering in swarms before sunset about the gables of houses, the more prominent portions of the taller plant growth, or they may even use the gardener's head as a rallying point. Occasionally these swarms—which seem to consist almost entirely of males—become a nuisance. In December 1936—January 1937, following heavy rains, this midge invaded dwellings in certain parts of the city in annoying numbers. *Forcypomyia,* together with certain other small flies, is often attracted to freshly painted surfaces.

In the mountains one often observes their swarms dancing alongside trees and bushes.

When enclosed in vials stoppered with moist cotton or cloth, *Forcypomyia* often laid masses of glassy white eggs shaped like fat cigars, the mass swelling on being placed in water. The eggs are about 0.30 mm. long. In less than a week they hatch into glassy white caterpillar-like larvae with a large head bearing reddish eyespots and some dark shade at the mouth and within the head, both head and body being provided with club-like hairs and hairs of ordinary type. A large horn-like pair, the antennae, adorns the head in front of the eyes. Well forward on the breast is a large pseudopod by means of which the insect drags itself along. The mandibles play with alternate down and backwards strokes.

A number of well-grown *Forcypomyia* larvae were observed in the upper part of Hering Valley behind Honolulu, and living speci-

mens were brought to the laboratory for study. As this odd-looking creature rests with the lower part submerged, upon a wet leaf or bank, we note on its back the pairs of thickened, mostly club-shaped hairs arising from darkish cones, and often bearing a droplet of moisture while along the sides, curved hairs appear to support the insect in its upright position. It is very shiny and gleams somewhat reddishly beadlike in the light. The curious large head that is carried rather upright is somewhat elongate and tapers to the square-cut mouth, the two dark eyespots with a horn-like antenna before each; all help in the writer's mind to give the larva of *Forcypomyia* a decidedly bovine countenance. A note of June 13, 1933, on several well-grown larvae may be rendered as follows: "This morning beside the tiny stream in Hering Valley I watched several *Forcypomyia*. They were travelling slowly on a very wet leaf, their curved lateral hairs apparently resting on the thin sheet of water seeming to steady them. At the tail end and probably functioning as a blood gill is the extrusible delicate tapering process that is hair-fringed basally and extends upon the water. Here too is a terminal rosette, and some fine hooks that probably serve for anchorage when necessary. No tracheae were discerned. As the larva slowly advances, it moves its head from side to side with the mouth applied to the smooth surface of the leaf, the thin, shell-like mandibles probably scraping off fine material. A large larva was observed tilting its head forward and bring its mouth on a level with the surface film of water, when the mouth-parts, brush-like were seen moving with so great a speed as to draw a current towards them. As *Forcypomyia* slowly moves forward—and it seems unable to go backward—its progress is seen to be of a somewhat trembling or finely jerky character, due to the repeated strokes of the duplex proleg under the thorax. There is no humping up and forward, such as takes place in caterpillars, visible here. When a larva meets another, one of these will swerve swiftly aside; in fact if sufficiently disturbed, it may swing over far enough to reverse its position. I found that the most satisfactory way of capturing these tiny creatures was to drive them onto a bit of wet leaf which could then be

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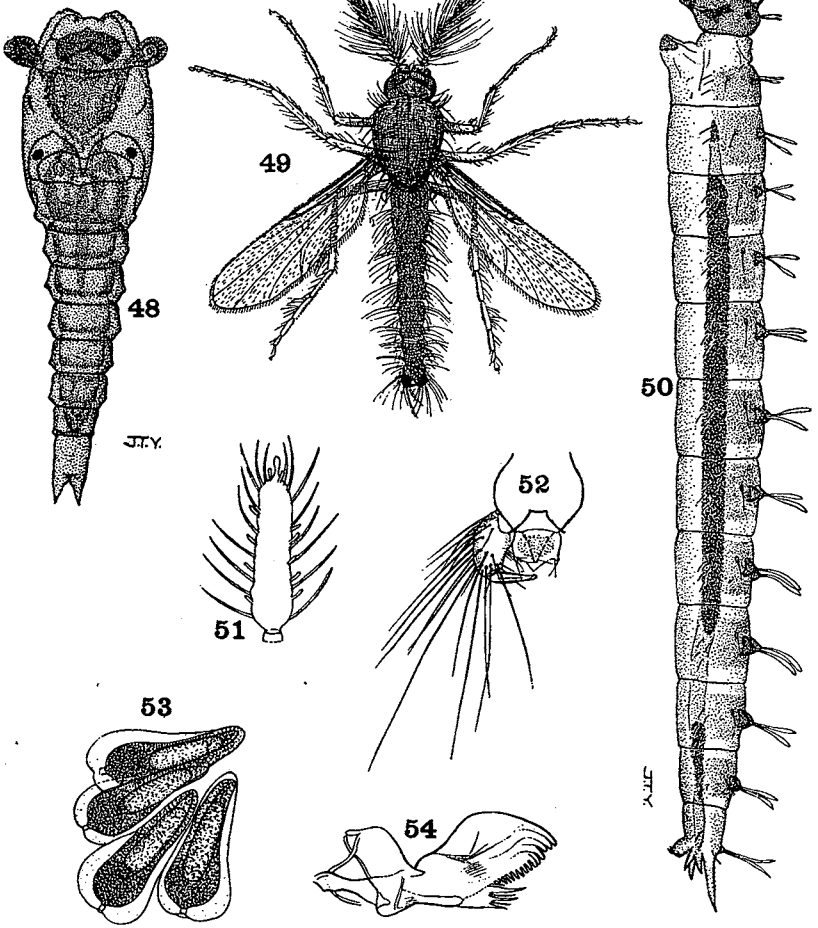
FORCYPOMYIA INGRAMI

Explanation of Plate VIII

48. Pupa, dorsal view.
49. Male.
50. Larva.
51. Male, last article of antenna.
52. Male, part of terminalia.
53. Egg cluster. Length of egg 0.45 mm.
54. Larval mandible.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lifted up. They float quite well, when they are able to make some progress by writhing very fast. Surface tension draws them quickly to nearby objects. They are helpless on a smooth surface under water.

In the laboratory the pale brownish pupae could be found, back up, upon a wet leaf, mass of algae, etc., the two, somewhat funnel-form respiratory trumpets protruding through the water film that covers the body itself. While apparently unable to swim, and indeed, open water is not their habitat, the pupae when turned over in the water so that the funnels are ventral and underwater, will by means of a jerk or a squirm or two, very neatly turn over on their back. The adult issues through a gaping crack made in the back of the pupa.

Forcypomyia ingrami breeds in a variety of situation. At Kilauea, Hawaii, in October 1929, Mr. O. H. Swezey secured a number of the adult flies from well-watered cabbages, between the leaf bases of which there was some detritus and decay and where no doubt the larvae were feeding. At Nauhi, Hawaii, in September 1931, *Forcypomyia* larvae were found at the base of the spathe of the calla lily (*Richardia aethiopica* Spreng., Araceae) where water and debris collect. The immature stages may be very common among wet leaves and trash in the forest as well as in the dense cover of the uluhi fern (*Gleichenia linearis* [Burmann] Clark).

The adult females of some species of *Forcypomyia* are known to suck the juices of other insects, notably the larvae and adults of lepidoptera, and to quote Edwards on *ingrami* (Insects of Samoa, pt. VI, Diptera, fasc. 2, Nematocera; 51, 1928): "In West Africa the larvae were found by Ingram to be semi-aquatic and to prey on mosquito larvae."

Among the enemies of this insect in Hawaii are dragonflies and damselflies, *Pantala flavescens,* for example, flying back and forth through the swarms of these midges, while their larvae are preyed upon by the nymphs of damselflies that occur in similar situations.

An excellent, finely illustrated paper on several species of *Forcypomyia* has been written by L. S. Saunders: "On the Life History and the Anatomy of the Early Stages of *Forcypomyia* (Diptera. Nemat. Ceratopogoninae)"; Parasitology, **16** (2): 164-213, 26 textfigures and 3 plates, 1924.

Dasyhelea hawaiiensis Macfie. (plate figures 60-63).

Macfie, J. W. S., Stylops, 3 (6): 133-134, 1 fig., 1934.

This tiny fly is about 1.25 mm. long and a sort of dark gray brown with the halteres conspicuously yellow. The male is more slender than the female and has plumose antennae.

The females may be seen in the daytime in low irregular zigzag flight, passing, or pausing over or alongside dripping wet banks that

are more or less clothed with such plants as dwarf ferns, moss, filamentous green algae, like *Cladophora,* and glistening, water-soaked masses of brown diatoms commonly of two kinds, the filaments of one made up, of waffle-shaped units, and those of the other, of deeply fluted sub-cylindrical ones. In addition, there would be fine intermingling soil, dead leaves and other organic matter.

Dasyhelea, difficult to follow because of her very small size, will alight upon a wet spot, walk a bit, perhaps fly off a few inches, hover, alight again, and for a while remain quiet. She was not observed in the act of oviposition, but her egg-masses are sometimes to be found attached to saturated algae alongside a thin waterfall, and captive flies often deposited eggs readily. The eggs, each enveloped in a clear elastic gelatinous substance, adhere to one another to the number of a few individuals to several dozen to form subglobular masses (fig. 62). At first pallid, they turn a sort of smoky brown; they are rather firm of shell and although really elongate, are doubled up short, as if mindful of their stubby parent on the one hand and of the slender larvae that are destined to hatch from them, on the other. The eggs measure from about 0.20 to 0.25 millimeter in their longer doubled-up diameter, the projecting portion being the head end. In due time two eye spots and a sort of throat, or pharyngeal skeleton may be seen through the eggshell and a day or so later the tiny larvae hatch out. They have a pale brown head, but the body is nearly transparent and lacks any pseudopod or false foot. The mandibles may be seen under the fore part of the head in alternate down and backwards movement suggesting grappling hooks. Throughout its life of several weeks in a water-soaked, or even quite immersed mass of algae, diatoms, etc., it is unable to swim but can travel swiftly snake-like a short distance among the plant filaments, and here even the mandibles may assist in locomotion, when it must pull itself along. There are a few erect hairs at and towards the tail end of the body, at the very extremity of which are four delicate tapering processes that are retractile and probably function as blood gills. A very delicate system of fine longitudinal tracheae is to be seen along the greater length of the body. Although no air was discernible within the larva, the latter went through motions—with its head to the surface—suggesting that it did drink in air.

When mature, the *Dasyhelea* larva is pale yellowish or orange brown and a little over 4 millimeters in length (fig. 60). As the time for transforming into a pupa approaches, the thorax becomes clearer than the rest of the body and swells considerably but with its three divisions marked off by strong incisions, while beneath the skin of the prothorax the two respiratory trumpets of the pupa

extending obliquely from back to breast, are clearly visible. During the act of pupation—which is quite rapid—these two long ear-like organs flip up simultaneously, being released as the old larval skin slips off the pupa. The light brown pupa, heavier than water and rather sluggish, is quite unable to swim, though twisting its abdomen in a tortuous manner. Like the larva, it frequently remains in fine water-soaked plant growth where it is able to work its way among the tangle of filaments and keep the back of the distal part of the breathing trumpets to the surface, anchoring itself firmly against any current by means of the two laterally-projecting horns at the extremity of the abdomen. When the time for the emergence of the adult is at hand, the pupal skin splits at the head and thorax above and the tiny fly crawls out, clings for a time to the anterior end of the now rather distended pupal shell and then flies off. The top of the thorax in such freshly issued flies, as noted in a female, is a rich brown color.

This insect has been found from nearly sea level to an altitude of over 2000 ft. Its larvae may be very numerous among algae thinly covered by flowing water, and I suspect that it is much preyed upon there by the nymphs of our large *Megalagrion oceanicum* damselfly.

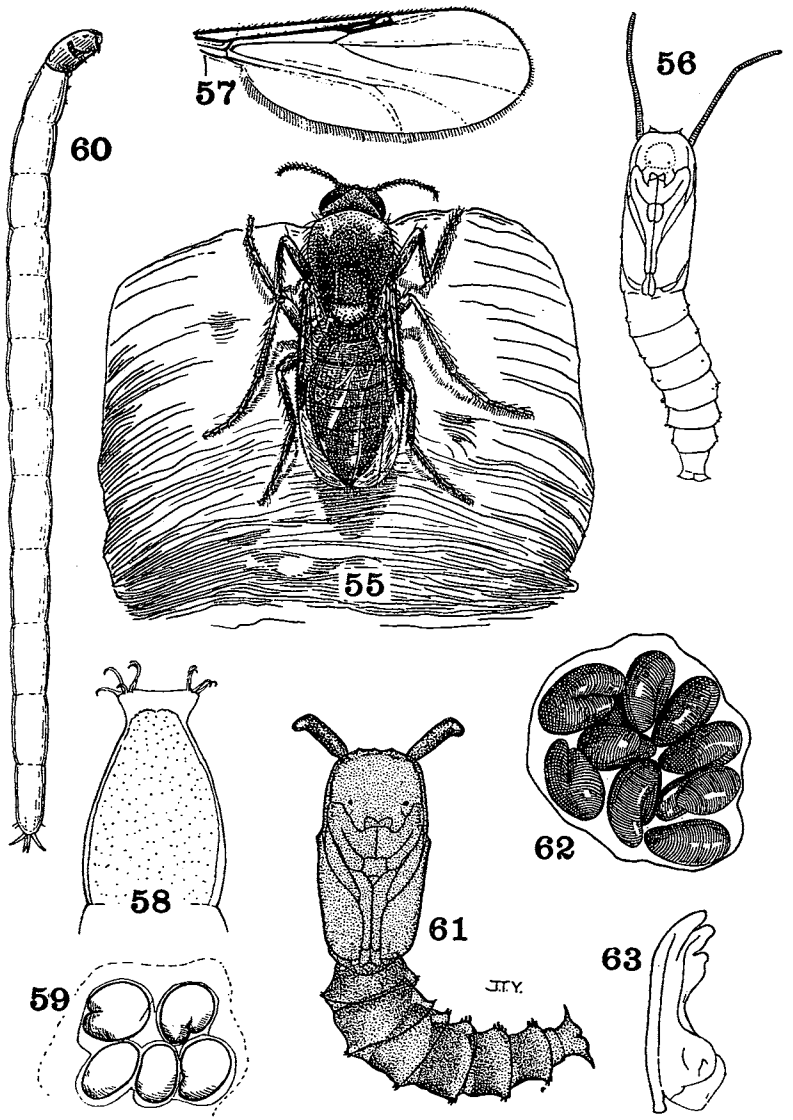
In addition to its dripping wet-bank habitat, this species also breeds in the leaf axils of *Dubautia laxa pseudoplantaginea* Skottsb. (family Compositae, tribe Senecionideae), a shrub that thrives in the cloud zone of our mountains. First observed on March 31, 1935 by Mr. O. H. Swezey (Proc. Hawaiian Ent. Soc., **9** (2) : 206, 1936), who refers to the insects found on this *Dubautia* "A few yellow mycetophillid (?) larvae were in moisture at the bases of the leaves", it has thus far been found in leaf axils far up the slopes of Mt. Olympus behind Honolulu. Both the larger larvae and the pupae are a sort of orange red. The pupal shells may be found on *Dubautia* leaves.

Further collecting will probably show that this insect is widely distributed over the higher parts of the Koolau Mountains.

DASYHELEA

Explanation of Plate IX

55. *Dasyhelea calvescens,* female. Length about 1.6 mm.
56. *Dasyhelea calvescens,* pupa.
57. *Dasyhelea calvescens,* male wing.
58. *Dasyhelea calvescens,* larva, caudal end; not all the hooks are shown.
59. *Dasyhelea calvescens,* egg cluster. Egg about 0.18 mm. long.
60. *Dasyhelea hawaiiensis,* larva, last stage. Length 4.05 mm.
61. *Dasyhelea hawaiiensis,* pupa.
62. *Dasyhelea hawaiiensis,* egg cluster. Length of egg 0.21 mm.
63. *Dasyhelea hawaiiensis,* larval mandible.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Dasyhelea calvescens Macfie. (plate figures 55-59).

Macfie, J. W. S., Proc. Zool. Soc. London, series B, taxonomy, 7: 157, 158, 1938. Described from Hanauma Bay, Oahu, May and June 1936.

To quote Dr. Macfie (l.c.: 157): "A small very dark brown or blackish species, with wings almost entirely devoid of macrotrichia, scutellum very dark brown, halteres with white knobs and femora and tibiae dark brown." The posterior part of the scutum is rather depressed mesad, and this part and particularly the scutellum are of a paler shade. Length about 1.6 mm.

This maritime midge may be the species found by J. C. Bridwell in a salt marsh at Waikiki, Honolulu, May 30, 1919, and referred to by him as a species of *Ceratopogon* (Proc. Hawaiian Ent. Soc., 4: 284, 1920).

It is common along the shores of Oahu appearing in the hot sunshine, buzzing in tiny, more or less zigzag movements close over the rocks back of the beach or nearer the upper tidal zone.

It is an insect of the highest tidal zone and of salt water canals (the Ala Wai canal). It also breeds in the upper splash pools. The female midge when freshly hatched has a distinct orange tinge. Eggs were secured in December 1939 from flies taken about the low tide level along the Ala Wai canal. Here *Dasyhelea* was running and flying, almost hugging the exposed area that was plentifully supplied with fine low algal growth, and with white tooth-like barnacles also present. The eggs, each enveloped in clear jelly, are laid in small globule-like batches. They much resemble the eggs of *Dasyhelea hawaiiensis* but are not so dark and measure about 0.18 mm. long. The larva is very slender and is provided with grapple-like hooks posteriorly. It shows some ability to swim. The pupa has very long breathing horns and a pair of stout, laterally spines posteriorly. Both larva and pupa are orange.

This midge is preyed upon by *Cymatopus acrosticalis* Parent, the dolichopodid fly that patrols the sea rocks.

PART IV

LEPIDOPTERA OR MOTHS AND BUTTERFLIES

There are many kinds of lepidoptera, the caterpillars of which feed upon aquatic plants, but the ones that are modified for an aquatic or subaquatic life are relatively few. These belong to the moth family Pyralidae, and live upon such plants as rice (*Oryza*), pond weed (*Potamogeton*) and water lilies (*Nymphaea*). In addition to the above species that inhabit quiet waters, there are a few others that are found, both as larvae and pupae, wholly submerged in swiftly running water. Here the larvae live beneath sheets of

spun silk and feed on algae. (Lloyd, J. T., "Lepidopterous Larvae from Rapid Streams"; Journ. New York Ent. Soc., 22: 145-152, 2 pls., 1914. *Elophila fulicalis* Clemens, in New York State). Another interesting species of much the same habits is *Aulacodes simplicialis* Snell that was observed by Messrs. F. Muir and J. C. Kershaw in 1908, in a mountain stream in Lappa, "a mountainous island on the western side of the harbour of Macao", China. The larvae lived sometimes at a depth of 18-24 inches under swiftly flowing water. The cocoon is so constructed as to allow the passage of water through it and at the same time keep the pupa dry. And to quote, on p. xliv: "The adult moth readily takes to water when frightened, diving below the surface and using the legs for swimming—" (Notes on the Life-History of Aulacodes simplicialis Snell"; Proc. Ent. Soc. London, 1909: xl—xliv, 4 figs. Transmitted by Prof. E. B. Poulton).

The flightless form of the female of the European *Acentropus niveus* Ol., the larva of which lives on *Potamogeton,* passes its life in the water. It swims, by means of its modified posterior legs, near the surface of the water where it mates with the male, then sinks, lays her eggs on the submerged plant and dies. (See Karny, H. H. "Biologie der Wasserinsecten": 159-160, fig. 102, 1934 [aus Lampert]).

The genus *Nymphula* (= *Hydrocampa*) is widely distributed and contains numerous species, a few of which are rice pests. Their larvae are often provided with fine filamentous gills along the body, and to facilitate respiration under water such larvae are described as performing regular undulatory movements—as do *Chironomus* fly larvae.

Further literature on this group of moths is as follows:

Reamur, R. A. F. de. "Memoires pour Servir a L'Historie des Insectes, Tome 2, Dixieme Memoire. Des Chenilles Aquatiques": 391-406, pl. 32, 1736. A species of *Potamogeton.*

Miall, L. C. "The Natural History of Aquatic Insects", 1895. Aquatic Caterpillars: 226-235, 1 fig. *Hydrocampa nympheata* (Linn.), *Cataclysta lemnata* (Linn.), *Paraponyx stratiotata* (Linn.), etc.

Hampson, G. E. "Fauna British India", Moths, 4, 1896. On pp. 187-241, subfamily Hydrocampinae.

Hart, C. A. "On the Entomology of the Illinois River and Adjacent Waters", Bull. Ill. State Lab. Nat. Hist. 4(6), 1896, Lepidoptera on pp. 164-183 and 278, pls. 1 and 2. *Paraponyx obscuralis* Gr., *Hydrocampa obliteralis* Walk., etc.

Maxwell-Lefroy, H. and Howlett, F. M. "Indian Insect Life", 1909. *Nymphula depunctalis* Guen., p. 515-516; colored plate.

Needham, J. G. and Lloyd, J. T. "The Life of Inland Waters", 1916: 218-220.

Sison, P. "Observations on the Life History, Habits and Control of the Rice Caseworm, *Nymphula depunctalis* Guen." Philippine Jour. Agric., **9**: 273-301, 4 pls., 1938. Also feeds on *Panicum* sp., *Paspalum* and *Eragrostis*. Life cycle, 21-37 days.

Nymphula fluctuosalis Zeller. (plate X).

Zeller, K. Vet.-Ak. Handl.: 27, 1852.

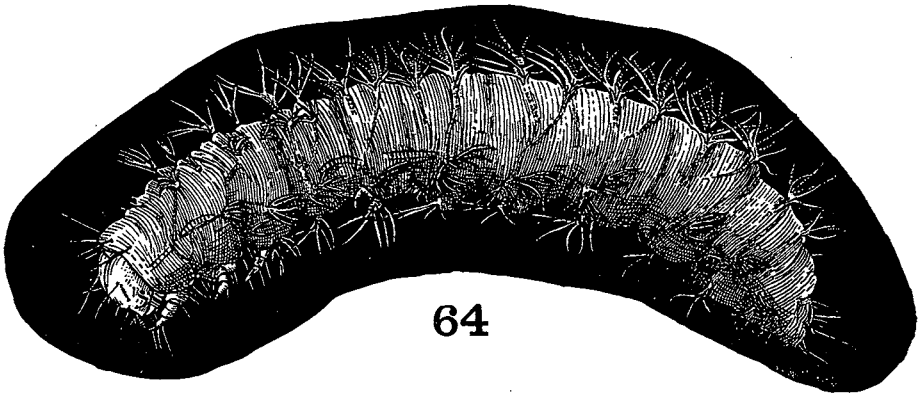
"*Hab.* Throughout the tropical and subtropical zones, on the north to Formosa and Sandwich Islands, on the south to Australia". (Hampson, "Faun. Br. India" Moths, **4**: 194, fig., 1896).

This moth occurs on the larger islands of the Hawaiian group. The earliest record of its presence here seems to be that given by Butler in May 1879 under the title: "On Heterocerous Lepidoptera collected in the Hawaiian Islands by the Rev. T. Blackburn", (Ent. Mo. Mag., **15**: 270, 1878-9), the moth being under the name of "*Oligostigma curta,* n. sp." Following its description, Butler quotes Blackburn thus: "Not uncommon about grassy streams in mountain valleys, when such can be found, and that is seldom". It is a delicate whitish moth with fulvous bands on wings and abdomen. The wing expanse is from 16 to 21 mm.

The caterpillar is a case-bearer, and when rice was extensively grown here was somewhat of a pest on that crop. It also feeds on other grasses, and Mr. O. H. Swezey once found it damaging the leaves of water lilies (*Nymphaea*) in Nuuanu valley, Honolulu, in September 1932. The moth is often taken at light. It lays a number of flattish, rather elliptical yellowish eggs a little more than half a millimeter long. The young larva has a pair of long hairs on the dorsum of the terminal segment and there are also some sparse shorter hairs. Later on it acquires dorsally and laterally on the body, fine filamentous gills enclosing air tubes that join the longitudinal tracheal trunks. The pupa is formed within a case or cocoon and is not extruded at the eclosion of the adult. The larva is subaquatic.

NYMPHULA FLUCTUOSALIS
Explanation of Plate X

64. Larva, last instar.
65. Adult female. Expanse 17 mm.
66. Group of eggs.
67. A single dorso-lateral larval gill.
68. Pupa, caudal extremity, side view. Drawn from a dried specimen.



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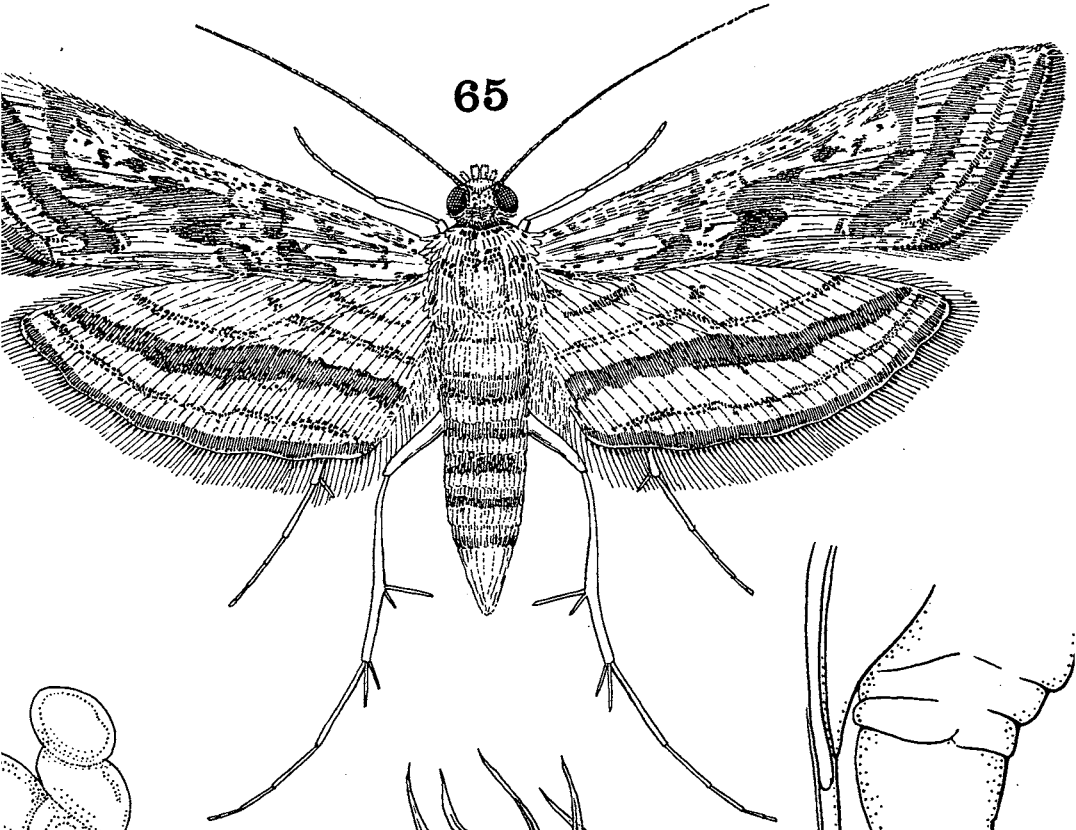

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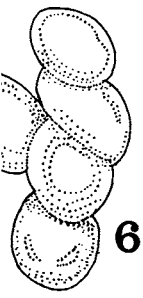

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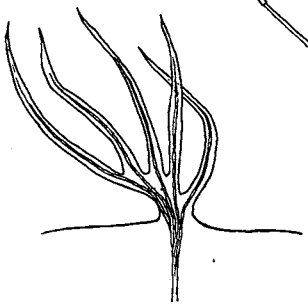

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Nymphula obliteralis (Walker). (plate XI).

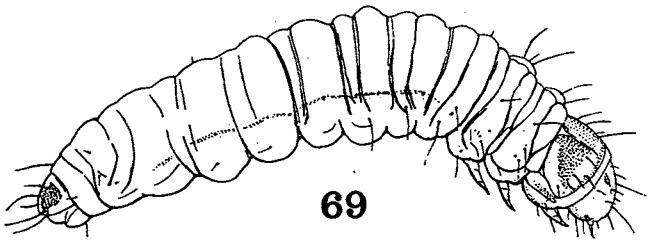
Walker, Cat. Brit. Mus., **17**: 399. Described from Florida and Texas; rather widely distributed in the United States.

A duskier and heavier moth than *N. fluctuosalis*. It is a recent and unwelcome immigrant in the Hawaiian Islands, having been first reported by Mr. D. T. Fullaway who reared it from water lilies (*Nymphaea*) in Honolulu early in 1942. Later in the year it was reared by O. H. Swezey and by F. X. Williams. (Proc. Hawaiian Ent. Soc., **11**: 277, 1943).

A group of eggs of this moth were found securely glued to the underside of a lily leaf close to the margin (fig. 71). They are low oval domes about 0.65 mm. long and of a whitish color. The larva at birth has a longitudinal tracheal system and some long simple hairs but does not later acquire filamentous gills (fig. 69). It does extensive though sporadic damage to lily leaves so that these become very ragged. It forms a case of pieces of the leaf and wanders about as a case-bearer, inflicting its unsightly damage also upon the flowers of the lily, and well merits the name "miserable sandwich worm" given it by my wife, copartner of a small lily pond. The larva also uses the leaves of other aquatic plants for making cases. A large larva 9 mm. long has a pale brown head, a darker narrowly fissate prothoracic shield and a dull pallid green body. The antennae are conspicuously porrect and there are sparse erect hairs on head and body. When under water the extruded fore part of the body dorsally, from the second segment, is beautifully silvered. The cocoon case is blunter at the fore end, and in issuing from it the moth makes a wide slit in the silk. In the laboratory the cocoon was securely fastened to the side of the glass container, just above the water line. The pupa has the spiracles on segments 2-4 of the abdomen large and protruding. For a good treatise on this insect the reader is referred to the work of C. A. Hart ("On the Entomology of the Illinois River and Adjacent Waters", Bull. Ill. State Lab. of Nat. Hist., **4**(6): 174-180, and 278, plate II, Dec. 1895-April 1896). Hart writes, p. 176: "The favorite home of this species is among the floating leaves of *Potamogeton nutans*, which often thickly cover the surface of quiet water in large patches."

NYMPHULA OBLITERALIS
Explanation of Plate XI

69. Larva, last instar.
70. Adult, a small, rather dark specimen. Expanse 11.5 mm.
71. Eggs on underside near margin, of *Nymphaea* leaf. Length of egg 0.65 mm.
72. Larva in case made of bits of *Nymphaea* leaf.
73. Pupa. Length 5.2 mm. Two views of second visible spiracle.



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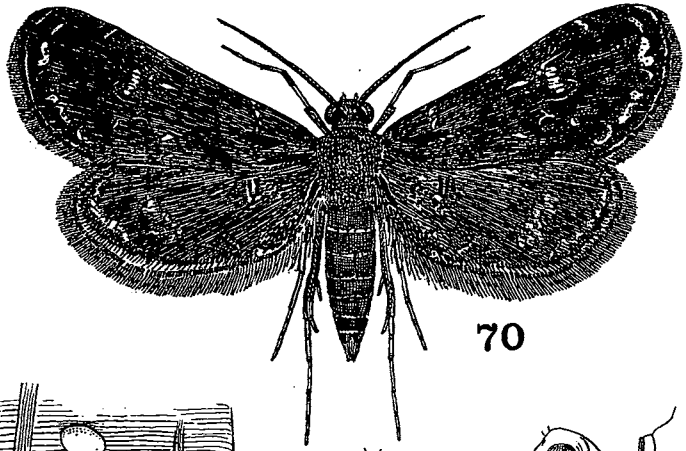

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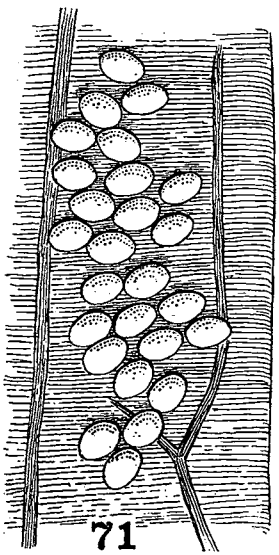

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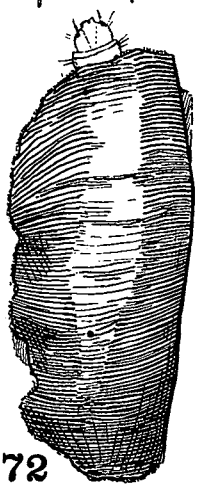

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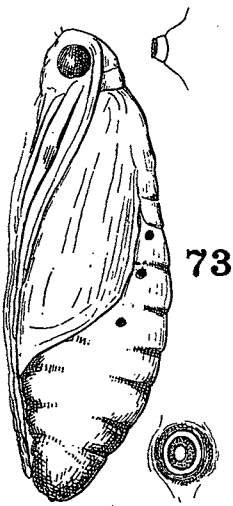

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PART V

HEMIPTERA OR BUGS

Water-loving bugs are poorly represented in the Hawaiian Islands. They fall naturally into several groups according to structure and habits, as follows:

1. **Saldidae.** Shore-bugs. Found along the edges of streams and pools in the forest, on mossy banks, on the forest floor and along mountain trails. Several species. All endemic.
2. **Hebridae.** The hebrids. On mats of algae in reservoirs, on the edges of stagnant pools, etc. Chiefly in the lowlands. A water-running bug, often submerging. One species. Immigrant?
3. **Mesoveliidae.** The mesoveliids. Active water-runners, but favoring algal mats, leaves of water plants and the edges of sluggish streams. Chiefly lowlands. One species. Immigrant.
4. **Gerridae.** In our case, pelagic water-striders. Offshore or open ocean. Two species. Endemic or indigenous.
5. **Veliidae.** The veliids or broad-shouldered water-striders. Active; widespread; reservoirs, sluggish streams, puddles, large artificial water containers. Favors algal mats, floating debris, etc. One species. Immigrant?
6. **Notonectidae.** The back-swimmers. Living in the water, reservoirs, ponds, pools in the forest, water troughs, etc. One species. Presumably immigrant.
7. **Corixidae.** The water-boatmen. Inhabiting chiefly the bottom of pools, in our case, preferably saline. One species. Not known elsewhere.

FAMILY SALDIDAE (text figure 8)

Our *Saldula* are broad little bugs from about 3 to 6 mm. long, brownish to black but with the hemelytra marked with pale window-like spots and dashes. The wings—under the hemelytra—may range from mere stubby rudiments to nearly or quite the length of the hemelytra. They are very active, hopping and running and some are able to fly a short distance. Five species and one variety are listed by Kirkaldy (Fauna Hawaiiensis, 3 (2) : 146, 1908, and

t.c., pt. ibid 2 (6) : 554, supplement to Hemiptera, 1910) under the genus *Acanthia,* as follows:

Acanthia exulans (F. B. White).
Acanthia oahuense (Blackburn).
Acanthia oahuense (Blackburn), var. *molokaiensis* Kirkaldy.
Acanthia humifera Kirkaldy.
Acanthia nubigena Kirkaldy.
Acanthia procellaris Kirkaldy.

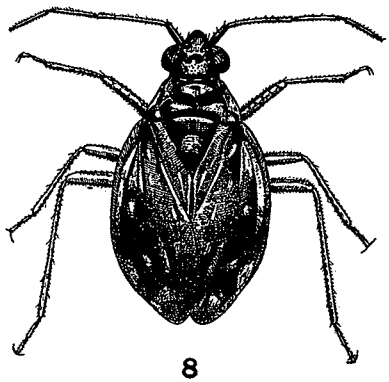

Fig. 8. *Saldula* sp., Hering valley, Honolulu. Enlarged.

This group however, is recognized as being badly in need of revision. In addition to the environment already mentioned, Dr. R. C. L. Perkins has upon occasion found *Saldula* to be to some extent arboreal (Fauna Hawaiiensis, 1 (6), Introduction: cciii, 1913). Practically nothing has been published as yet on the developmental stages of our species. Dr. R. L. Usinger has succeeded in rearing an Oahuan *Saldula* from egg to adult (Proc. Hawaiian Ent. Soc., 9: 359, 1937).

Although *Saldula* can easily maintain itself upon the surface of the water, it seems unwilling to do so and quickly makes for shore. It is carnivorous in its habits, and I have seen it in Manoa valley probing algal covered boulders for the larvae of Tipulidae or crane-flies.

FAMILY HEBRIDAE

Merragata hebroides White. (text figure 9).

White, F. B., Ann. and Mag. Nat. Hist. (IV) 20: 114, 1877. "On small stagnant pools formed by the temporary overflow of

streams on the higher mountains. When the pools dry up, the insect frequents the holes where the water has been."

This is a compact little bug about 2 mm. long. It is rather leisurely, even tedious in its movements, and its short water-skimming flights do not suggest much energy. *Merragata* is a common

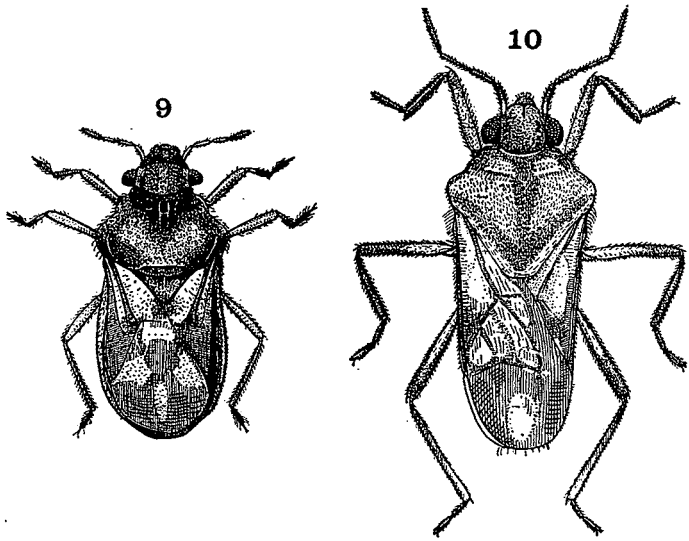

Fig. 9. *Merragata hebroides.* Length 2.20 mm.
Fig. 10. *Microvelia vagans,* alate form.

insect at puddles, along stagnant portions of streams and in reservoirs, occurring there on algae and algal blankets. Both young and mature bugs readily pull themselves under water, where they become conspicuous because of their air-silvered bodies. They may remain submerged for some time. In the laboratory one was seen sucking the juices of an immature one of its own kind that still showed signs of life. And here it was preyed upon by *Mesovelia vagans,* a larger water surface bug.

FAMILY MESOVELIIDAE

Mesovelia mulsanti White. (text figures 11, 12 and 13).

White, F. B. Trans. Ent. Soc. London, 1879: 268. "Hab. Rio Purus (September 24, 1874)". Amazons. Determined by Dr. H. B. Hungerford.

This slender active bug is 3-4 mm. long and of a generally yellowish green color. Adults may be winged or entirely apterous.

The winged form is the more slender and the ocelli are well developed. Its partly whitish wings render it rather conspicuous on its home of blankets of algae or on the leaves of aquatic plants. The apterous form has a wide suboval body while the ocelli are obsolescent.

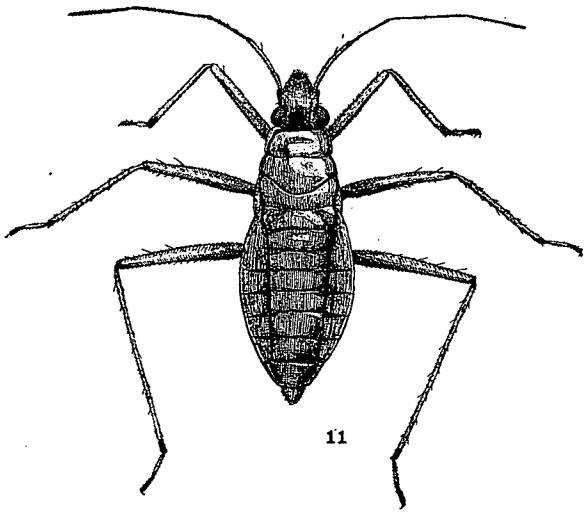

Fig. 11. *Mesovelia mulsanti,* apterous form.

Although the first record of the presence of this widespread American insect in Hawaii appears to be in 1933 (Proc. Hawaiian Ent. Soc., **8**: 378-379, 1933), when it was taken in a reservoir at Waipio substation, Oahu, it had probably been here for some years previous. It soon appeared in lily ponds and made its way into the mountains where it keeps to the sides and vegetation of the quiet stream pools.

Its biology was little studied. In New York and in Kansas, Hungerford ("Aquatic Hemiptera". Kans. Univ. Sci. Bull., **11**: 101-106; pl. XIV) gives a good account of this insect, the activities of which he studied under a binocular microscope. The insect is found upon floating vegetation and feeds upon the small organisms that come to the surface from below, or that fall upon it. Entomostraca (Crustacea) were thus speared at the surface of the water. The eggs are inbedded in the tissue of certain plants.

Pieces of algal mats, composed largely of *Hydrodyction,* from a lowland reservoir on Oahu were brought to the laboratory and placed in a jar of water. Little *Merragata* bugs and the active young of *Mesovelia* were found in it. Eventually, a young *Meso-*

velia was observed in this jar with an immature *Merragata* skewered on its beak. Although rather chary of the adults of this little bug, *Mesovelia* often pounced upon a young *Merragata,* sometimes holding it down with aid of a foot or grasping it loosely with the legs and probing it for a deadly thrust. Or, *Mesovelia* would use only its beak for the attack. The thrust was sometimes made in a leg joint and sometimes in the body itself; in any case *Merragata* collapsed almost immediately, folding up its legs. It would then be held aloft to be sucked of its juices.

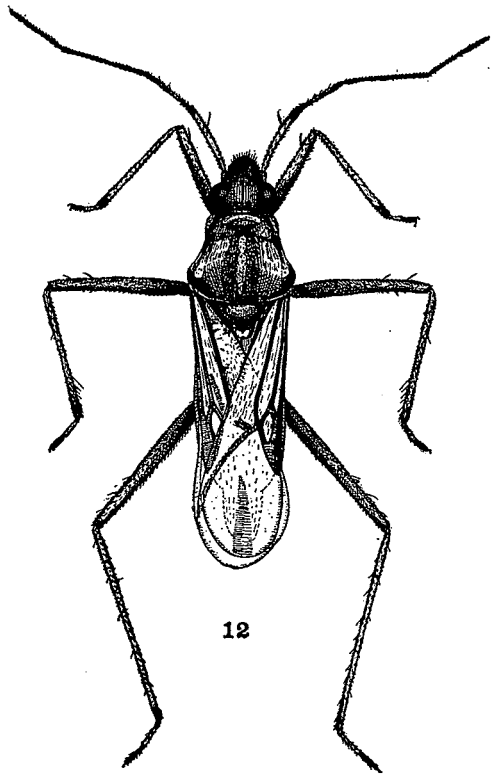

Fig. 12. *Mesovelia mulsanti,* alate form.

FAMILY GERRIDAE

There are no fresh-water striders of this family in the Hawaiian Islands. The pelagic water-striders are medium sized, entirely wingless insects, more or less grayish in color, with stout streamlined bodies and the middle pair of legs hair-fringed apically and

developed for great speed. They are common about tropical shores though also represented in temperate zones. They frequent lagoons and estuaries but may also be found far out at sea. Two species inhabit the Hawaiian area. The bather at Waikiki beach may have observed these insects as they speed over the surface of the water before him and occasionally executing a leap of an inch or two into the air. Certain inshore storms drive these insects in wind-rows along our beaches (Hadden, F. C., Proc. Hawaiian Ent. Soc., 6: 457-459, 1 fig., 1931).

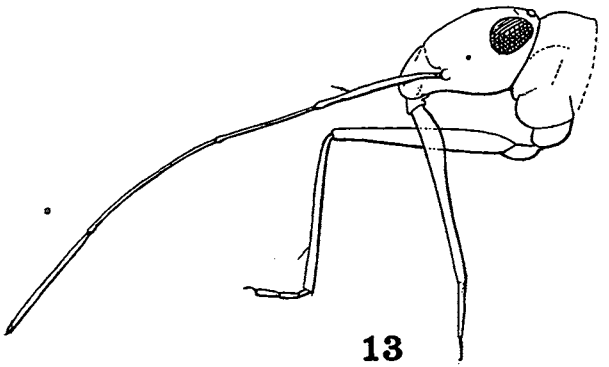

Fig. 13. *Mesovelia mulsanti*, profile of head.

It has been stated by some writers that *Halobates* can and does dive beneath the surface of the water; this faculty would then be useful in avoiding the full force of storms. Dr. R. L. Usinger who has devoted considerable study to these insects was unable to induce *Halobates* to dive beneath the surface ("Biological Notes on the Pelagic Water Striders [Halobates] of the Hawaiian Islands, with Description of a New Species from Waikiki [Gerridae, Hemiptera]"; Proc. Hawaiian Ent. Soc., 10: 77-84, 3 figs., 1938). I myself doubt that these insects do any diving and believe that many *Halobates* frequently perish in storms, as would likewise a certain proportion of other organisms under adverse conditions in nature.

Eggs of *Halobates* have been found on objects floating in the ocean in other parts of the world. Very young bugs may be observed along the seashores of Oahu.

Dr. Usinger found *Halobates* under captive conditions to be fiercely cannibalistic.

The two species found in Hawaiian waters are *Halobates hawaiiensis* Usinger (l.c., : 79-82) and *Halobates sericeus* Eschscholtz (Entomographien, 1: 108, tab. II, fig. 4, 1822). Dr. Usinger

found that *H. hawaiiensis,* characteristically gregarious, keeps within the protecting reef; *H. sericeus,* on the other hand is characteristic of the open ocean between the various islands. It is also listed from the Atlantic Ocean.

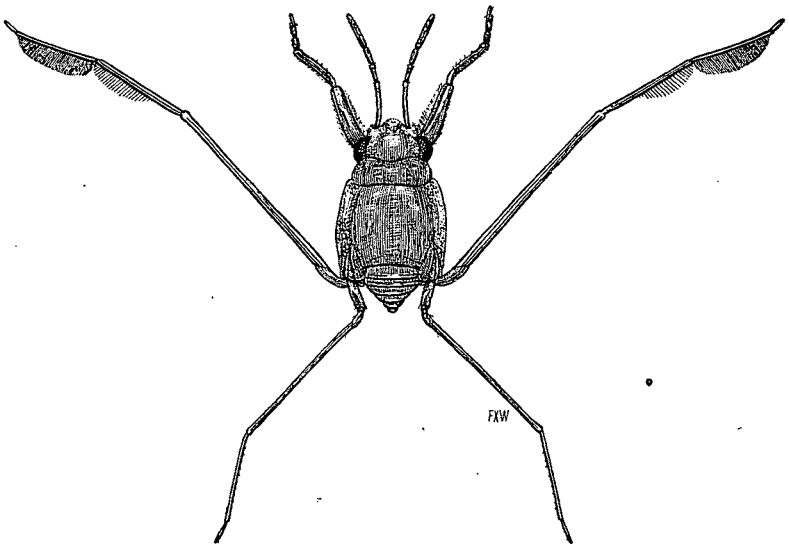

Fig. 14. *Halobates sericeus.* (After Hadden.)

FAMILY VELIIDAE

Microvelia vagans White. (text figure 10).

White, F. B., Ann. and Mag. Nat. Hist., (V) 1: 374, 1878.

This very common little bug is widely distributed in the Hawaiian Islands. It measures about 2.3 mm. long and is represented by both apterous and winged forms. It can be found on stagnant pools, taro ponds, lily ponds, the edges of sluggish streams where there is plenty of algal growth, and even in street gutters in wet districts. It will also find its way into tanks and other large water containers. It is not always on the surface of the water but patronizes the wet leaves and rocks nearby. A fiercely predaceous insect, *Microvelia* gangs up on chironomid flies as these emerge from their pupae at the surface of the water, and may overcome crane-flies issuing from some moss or algal growth. In the cool Mountainview region of the island of Hawaii, in October 1933, I witnessed successful attacks by *Microvelia* on the large pale, dark spotted collembolan, probably *Salina,* that so often finds its way into pools with steep banks. *Salina* is an active leaper upon the surface of the water, nevertheless the bug succeeds in stabbing it in the back, or

it would rush at it from the side. Once stabbed, *Salina* immediately collapsed. The presence in this pool of many dead and sucked-out *Salina* attested to the success of *Microvelia*. Many podurans of lead color were also found dead here, although they did not appear to have been fed upon.

Microvelia lays her eggs on dead leaves in pools, or elsewhere in the wet. The tiny red young may show silvery bubbles of air within the body, and a recently hatched individual clinging submerged to a leaf was observed with its proboscis at the surface, adding bubbles to its supply.

A good biology of *Microvelia borealis* Bueno is given by its describer in Ent. News, **28**: 354-359, 1 pl., 1917.

FAMILY NOTONECTIDAE

The backswimmers are represented in the Hawaiian Islands only by the foreign *Buenoa pallipes* (Fabricius, Syst. Rh.: 103, 1803), (text figure 15), an insect that is commonest in the lowlands but ranges into our mountains to several thousand of feet altitude. It is a pale shining insect with some reddish; well streamlined, and the posterior legs developed for rapid oar-like strokes. The two anterior pairs of legs are relatively small and generally hidden when the insect is viewed from the dorsal side. These legs function as baskets in which to hold an armful of food; to quote Hungerford relative to the food habits of *Buenoa margaritacea* Bueno, a species common on the mainland of the United States (Kansas Univ. Sci. Bull., **11** (17): 194-195, 1919) *"Food Habits.* One striking point in their biology is the adaptation of their two slender anterior pairs of limbs to food getting. The food of these insects of the small entomostracan Crustacea, and the four anterior limbs are margined with rather long spines which form when flexed a splendid crib for the retention of these little animals". Hungerford goes on to say: "They sometimes attack other insects, such as Corixids, but rely almost exclusively upon the little organisms named."

Buenoa while rising from time to time to the surface to renew its air supply, habitually keeps some inches below the surface, maintaining its position there by timely strokes of the posterior legs. Some of our lowland reservoirs teem with tiny crustacea, a *Daphnia*-like species for example being found in veritable clouds some distance beneath the surface. Ostracoda may also abound. Here *Buenoa* thrives. A particularly fine habitat for this bug was discovered many years ago at Haleiwa, Oahu. There on the flat lowlands was a shallow marshy pond already encroached upon by reeds,

succulent *Herpestis* (Scrophulariaceae), etc. It swarmed with small aquatic life. *Buenoa pallipes* (Fabr.) was present in all stages; *Arctocorixa, Merragata* and *Microvelia* abounded; here and there were *Enochrus nebulosus* (Say), a small hydrophilid beetle; the nymph of the endemic lowland damselfly, *Megalagrion xanthomelas* Selys, quantities of the common *Anax junius* Drury dragonfly and veritably swarms of *Pantala flavescens* (Fabr.), our abundant brown dragonfly. In addition, there were plenty of bloodworms (Chironomidae) and smaller organisms.

In captivity *Buenoa* quickly killed and fed upon the larvae of mosquitoes.

The males of *Buenoa* possess the power of stridulation; in *B. pallipes* the sound produced resembles the fine ticking of a watch, or the stridulation of certain small species of locustid grasshoppers,

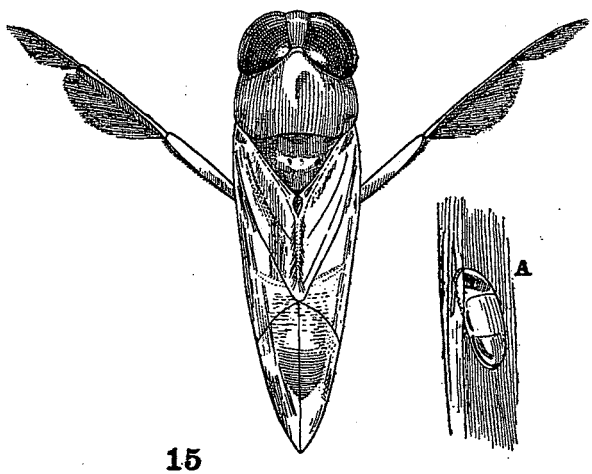

Fig. 15. *Buenoa pallipes;* A, egg embedded in plant tissue.

and it is audible from a distance of several feet. This sound is produced "When the fore limbs are brought up to the head, it will be seen that the stridular areas of the limbs meet those on the base of the beak". (Hungerford, l.c., re *B. margaritacea*).

The eggs of our *Buenoa* were found imbedded in plant tissues.

Unlike *Arctocorixa* in Hawaii, *Buenoa* seems quite unable to endure salt water.

FAMILY CORIXIDAE (The Water Boatmen)

Arctocorixa blackburni (White). (text figure 16).

White, F. B., Ann. and Mag. Nat. Hist., (IV) **20**: 114, 1877; ibid (V) **1**: 366, 1878. (*Corixa blackburni*) Kirkaldy, G. W., Fauna Hawaiiensis, **2** (6): 554, 1910. (*Arctocorisa blackburni*).

Of this insect, Dr. R. C. L. Perkins says (Fauna Hawaiiensis, 1 (6), Introduction: cciii, 1913): "This family is represented only by *Corixa blackburni* White, a species not known from elsewhere. It is very widely distributed on the lowlands of the islands, inhabiting salt-water pools as well as ponds of fresh water. It comes to light at night sometimes in considerable numbers."

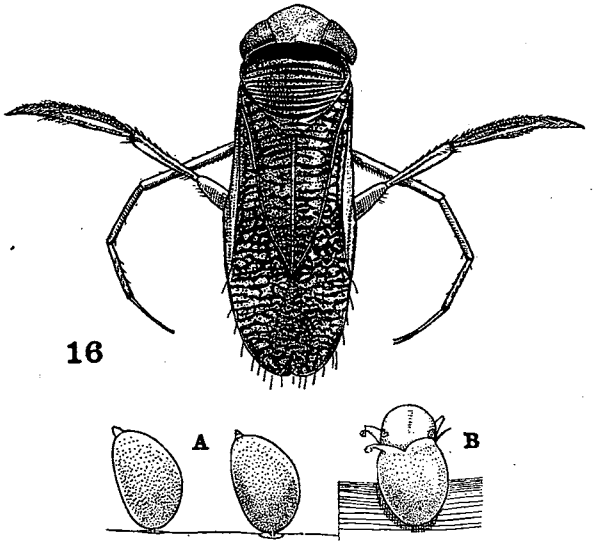

Fig. 16. *Arctocorixa blackburni;* A, eggs; B, young hatching from egg.

Our water boatman measures about 4.5 mm. long. The back of the thorax is finely banded with blackish while the elytra are finely but irregularly banded with brownish to black. The long posterior legs are hair fringed for propulsion by swift strokes.

Although the water boatman has been taken in a clear stream at over 2000 ft. elevation on Molokai, I have found it numerous only in the lowlands. It may fairly swarm in salty pools separated from the ocean by a low sandbar and having a salinity of approximately 5 per cent, or saltier than the sea itself. In this same salty medium we may find *Enochrus nebulosus,* the hardy little hydro-

philid beetle. *Arctocorixa* also thrives in lowland ponds on a base of mud and coral and where the water is fresh or nearly, and well stocked with other aquatic insects. The bug seems not to suffer from the presence of small fish that share the pool. It is a bottom insect, coming to the surface only for air or to take flight. I have seen swarms of this insect, nearly all immature, swimming steadily and mainly in one direction in a salty pool by the sea beach. The short-stemmed eggs are secured to submerged algae or other available material; they may be present in great quantity and appear like little white beads. I have kept *Arctocorixa* in sea water for over two weeks, and have seen a single individual at Waikiki swimming and diving in shallow water about 130 feet out from the shore.

It is probably chiefly herbivorous, as Hungerford has shown for other species (Kansas Univ. Sci. Bull., **11,** Aquatic Hemiptera, 234-249, 1919).

Our corixid often takes flight in the daytime. It would seem that the shining surface of water attracts *Arctocorixa,* and we have seen them in the bright sunshine crashing against the polished hood of an automobile, evidently mistaking the shining metal for their proper element.

Corixidae produce a chirping sound much as do the Notonectidae.

ADDENDA

Since commencing these papers on Hawaiian water-loving insects, other aquatic or subaquatic insects have appeared in the Territory, or have been overlooked. The following are now listed:

Order **COLEOPTERA**

Family CURCULIONIDAE

Stenopelmus rufinasus Gyllenhal.

Mr. E. C. Zimmerman has the following to say regarding this small robust insect:

"Four specimens of this semi-aquatic weevil were collected by Dr. H. Lyon from *Azolla* at Honolulu, in November 1909. It has remained undetermined in the Sugar Planters' collection and has evidently not been collected since that time. It may not have been established here, but it is worthwhile to record it. Its small size and peculiar biology, however, may have kept it hidden from collectors. . . ." (Proc. Hawaiian Ent. Soc., **10**: 131, 1938). It is widely distributed in the United States.

Order **TRICHOPTERA**
Family HYDROPTILIDAE.

Oxyethira sp.

This interesting find was made by Mr. E. C. Zimmerman in October, 1940, in Moanalua Gardens, Honolulu. (Proc. Hawaiian Ent. Soc., **11**: 350-352, 1943). He collected "a series of a minute, moth-like insect flying about at noon day near the banks of a small garden stream and nervously running about on the bare ground and searching into cracks in the soil. . . ." "The species is evidently not American, and is unknown to Nathan Banks, who kindly examined it. . . ." "It is probable that this species of *Oxyethira* has gained entrance to Hawaii by accompanying imported aquatic plants. . . ."

Order **ODONATA**
Suborder ZYGOPTERA
Family COENAGRIONIDAE

Enallagma civile Hagen.

This is a small damselfly, the male with the abdomen blue with black bands, the female of duller coloration, the abdomen being somewhat grayish. This insect was so outstandingly distinct in facies from our own fine species that it was immediately recognized as an intruder in the Hawaiian odonate fauna. The first record of its capture here is July 4, 1936, when a male specimen was taken on a hillside in Manoa valley, Honolulu (Proc. Hawaiian Ent. Soc., **9**: 368, 1937). It soon became very abundant in Honolulu and appeared on some of the other islands. It is common about reservoirs, lowland swamps and other bodies of water and may be seen in numbers in waste places and in gardens where there are no breeding places for it apparent. We find it also on the summits of mountains behind Honolulu.

Ischnura posita (Hagen).

Mr. Charles Hoyt of Honolulu first found this very small damselfly here. It was breeding in the Punahou School lily pond, Honolulu (Proc. Hawaiian Ent. Soc., **9**: 370, 1937). It is now an abundant insect. It is common on the mainland of the United States. Our specimens were determined by Mr. John Cowley.

These two damselflies are probably of some economic importance as destroyers of mosquitoes. They gained entrance into the Hawaiian Islands presumably through the importation of aquatic plants.